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Comparative Analysis of Time and Cost Efficiency in Project Acceleration Strategies: A Case Study of the Construction of a Police Service Building

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ABSTRACT

Optimal time and cost management are fundamental factors in ensuring the success of construction projects. One effective approach to address the risk of delays and cost overruns is the Time Cost Trade-Off (TCTO) method, which allows for project duration compression through resource adjustment and cost control. This study aims to analyze and compare two acceleration scenarios for the construction of the Police Service Building in Bungo Regency: additional working hours (overtime) and additional labor. This study uses a descriptive quantitative approach through a case study. The Critical Path Method (CPM) is applied to identify the critical path as the basis for implementing the TCTO strategy. The results of this study indicate that both scenarios can accelerate the project duration from 214 days to 130 days, with a time efficiency of 39.25%. The overtime scenario provides a cost efficiency of 0.38%, while additional labor results in an efficiency of 0.16%. Although overtime is more economical in nominal terms, the additional labor strategy is considered more stable and feasible to implement in public projects with sufficient work space. The results of this study contribute to strategic decision-making in data-driven construction project management.

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1. INTRODUCTION

The construction industry has a strategic role in infrastructure development which contributes directly to economic growth and improving the quality of public services (Hegazy 2002). In the Indonesian context, challenges in managing construction projects are not only related to the scale of the

project, but also to resource limitations, diverse geographical conditions, and the limitations of standardized project management systems.

Hegazy (2002), through a project management approach based on critical path analysis and time-cost optimization, provides an important framework for developing realistic and efficient project scheduling. This approach is highly relevant for public construction projects in Indonesia, especially on a medium scale, where time and budget constraints are key pressures. Many local government projects experience delays due to weak integration between planning and implementation in the field. Therefore, this study emphasizes the importance of adopting structured, data-driven project management principles as developed by Hegazy.

Research by Sarwani et al. (2024) identified that 90% of EPC projects managed by state-owned enterprises in Indonesia experience delays. The main contributing factors are the selection of tender winners based on the lowest price far below the estimated value, ineffective project planning, and weak coordination between implementing parties. Using the Relative Importance Index (RII) method, it was found that delays in material procurement and contractor inability to secure funding were the factors with the highest RII scores, underscoring the importance of a more structured and data-driven project management approach in the public sector.(Sarwani et al. 2024).

A study by Permadi et al. (2025) on a road maintenance project in Blitar City showed that an acceleration strategy through additional working hours (overtime) can reduce project duration by up to 8.6%, with additional costs still lower than potential delay penalties. This finding strengthens the relevance of the TCTO method in optimizing the duration of medium-scale public infrastructure projects in Indonesia.(Eka Shodiq Permadi et al. 2025).

Research by Purnomo et al. (2024) shows that an acceleration strategy by adding overtime on the critical path can shorten the project duration by 8 days with measurable additional costs. This study used the CPM and TCTO methods in a regional government agency (OPD) office building construction project in Pasuruan Regency and showed that installation and plastering activities were the most efficient acceleration points based on crash slope calculations.(Purnomo et al. 2024).

On the other hand, construction projects in Indonesia often face serious challenges in managing time and costs. Delays in implementation are a common problem, particularly for medium-scale public projects facing high schedule and budget pressures.(Luthan et al. 2024)Luthan et al. identified two dominant factors causing the delays: production and managerial factors. Production factors, such as delays in material procurement and implementation errors, recorded the highest Relative Importance Index (RII) value of 0.917. Meanwhile, managerial factors, such as slow decision-making and unclear technical specifications, recorded an RII of 0.895. These findings demonstrate the need for a more structured and responsive project control system.

In addition, factors such as uncertain weather conditions, shortages of skilled labor in certain fields, and logistical delays also contribute to deviations in construction project implementation schedules (Rahman et al. 2022). The use of conventional planning methods that are not data-based often results in schedules that are unrealistic, inaccurate, and difficult to control effectively (Hegazy 2002).

One quantitative approach that can be used to address this issue is the Time Cost Trade-Off (TCTO) method, which allows for the acceleration of activities on a project's critical path by adding resources (labor, overtime, or additional costs) in a controlled and measurable manner. This approach is often combined with the Critical Path Method (CPM) to produce a more realistic and measurable project schedule (Galagali 2017). Feng et al. (1997) using a genetic algorithm approach, proved that the resource-based TCTO model is capable of producing optimal solutions in terms of project time and cost efficiency (Biswas et al. 2016).

Sofia and Putri (2021) emphasize that acceleration strategies implemented through additional manpower tend to be more stable and secure than intensive overtime methods, which risk lower

productivity due to worker fatigue. In this case, the choice of acceleration strategy should consider not only duration but also efficiency and implementation risks in the field.(Sofia and Putri 2021).

Another study by Radinal et al. (2022) confirmed that time efficiency in project implementation can also be achieved through innovative material selection. In a case study of a university building, the use of Aluminum Composite Panels (ACP) as exterior wall cladding accelerated the construction time by up to four times compared to conventional methods, despite being almost twice as expensive. This demonstrates that project acceleration can be economically justified if it significantly impacts the building's completion and final quality (Radinal et al. 2022).

Unfortunately, although various studies have proven the effectiveness of the TCTO method and acceleration strategies, these approaches are still rarely applied systematically in public construction projects at the local government level. Therefore, this study aims to analyze the effectiveness of two acceleration strategies (additional working hours and additional labor) using the TCTO approach based on the CPM method. The results of this study are expected to provide recommendations for efficient, realistic, and applicable acceleration strategies, especially for medium-scale public construction projects in Indonesia.

2. METHODS

This research uses a descriptive quantitative approach through a case study of the Bungo Regency Police Service Building construction project. The objective is to compare two project duration acceleration scenarios using the Time Cost Trade-Off (TCTO) approach. The analysis was conducted using the Critical Path Method (CPM) to determine the activities on the critical path. The general methodology flow is depicted in Figure 1.

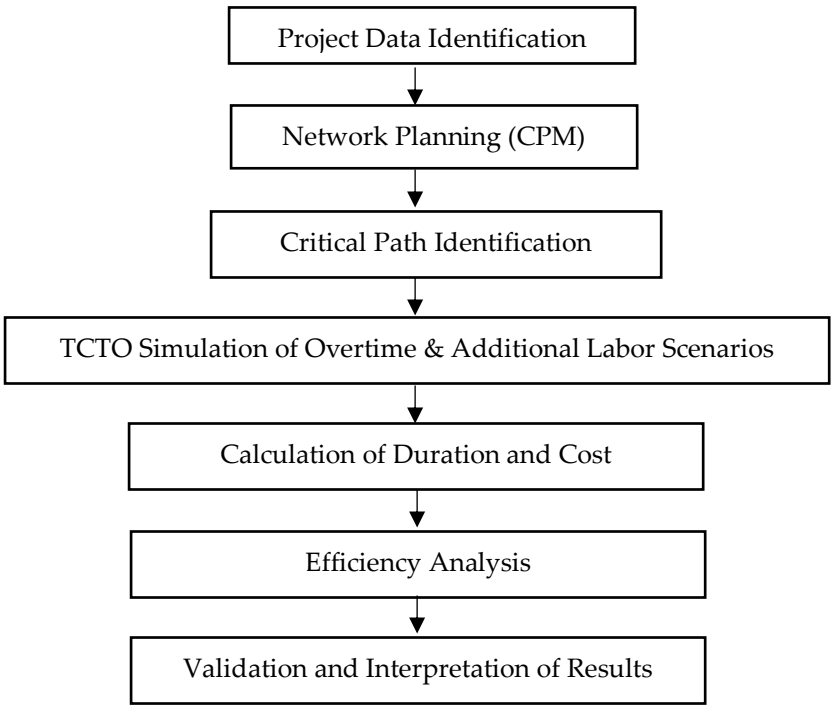

Figure 1. Research Methodology Flowchart

This research uses a descriptive quantitative approach through a case study of the Bungo Regency Police Service Building construction project. The objective is to compare two project duration acceleration scenarios using the Time Cost Trade-Off (TCTO) approach. The analysis was conducted using the Critical Path Method (CPM) to determine the activities on the critical path.

3. FINDINGS AND DISCUSSION

Duration and Cost Simulation Results

Simulations were conducted to compare the effectiveness of two project acceleration scenarios, namely: (a) additional working hours (overtime), and (b) additional labor, using the Time Cost Trade-Off (TCTO) approach based on the Critical Path Method (CPM). Activities on the critical path were analyzed and prioritized for crashing, based on the efficiency ratio between time savings and additional acceleration costs. This approach refers to the cost slope principle, where activities with the lowest acceleration costs per unit time are selected first (Galagali, 2017).

The simulation was run using Microsoft Project software, which was chosen for its ability to calculate critical path duration, total float, and systematically manage acceleration scenarios through resource leveling and crashing analysis (PMI, 2017). Activities with the lowest crashing cost per unit time ratio were selected first. In the overtime scenario, a maximum of two hours of work was added per day for the Structural Column and Floor Slab activities. In the additional workforce scenario, the number of workers was increased by 25–40%, assuming a linear increase in productivity.

The simulation results show that the project duration can be reduced from 214 days to 130 days, with a time efficiency of 39.25%. In terms of costs, the overtime strategy produces an efficiency of 0.38% with a total project cost of Rp 2,988,600,000, while the additional workforce strategy produces an efficiency of 0.16% with a total project cost of Rp 2,995,200,000.

Table 2. Comparison of Project Duration and Cost Based on Acceleration Scenario

Scenario	Duration (Days)	Project Cost (Rp)	Time Efficiency (%)	Cost Efficiency (%)
Normal (No Acceleration)	214	3,000,000,000.00	–	–
Overtime	130	2,988,600,000.00	39.25	0.38
Add Workforce	130	2,995,200,000.00	39.25	0.16

Furthermore, a sensitivity analysis was conducted on two key variables: overtime wage fluctuations and variations in labor productivity. Simulations show that a 10% increase in overtime wages reduces cost efficiency to 0.22%, indicating that the overtime strategy is more sensitive to changes in external costs. Conversely, the labor addition strategy exhibits relatively better stability, especially in medium-term project scenarios with sufficient workspace capacity.

These findings align with a study by Galagali (2017), which showed that time efficiency in public construction projects using the Time-Cost Trade-Off (TCTO) approach is generally in the range of 30–40%, while cost efficiency tends to be lower, generally below 0.5%. This suggests that accelerating project duration is indeed easier to achieve than achieving significant cost efficiency, given the additional resources required.

Thus, the results of this simulation are not only realistic, but can also be used as a strong basis in managerial decision making, especially in government construction projects that are faced with budget constraints but are required to complete work in a faster time.

Acceleration Strategy Discussion

From a managerial perspective, a workforce augmentation strategy is considered more appropriate for projects with adequate workspace and requiring medium- to long-term operational stability. This approach allows for more equitable workload distribution and reduces the risk of burnout that often occurs with intensive overtime strategies (Underdahl et al., (2024).

Although the overtime strategy demonstrated higher cost efficiency in nominal terms (0.38%), this method has limitations from a human factor perspective, particularly related to decreased productivity due to long additional working hours and the increased potential for technical errors (Ernst et al., (2019). Therefore, when making decisions, it is important to consider the balance between speed of implementation, cost efficiency, and stability of work quality in the field.

According to the Project Management Institute (PMI, 2017), an effective Time Cost Trade-Off (TCTO) approach should not only focus on cost and duration savings, but should also maintain the integrity of the dependency structure between activities in the project network. Feng et al. (1997) also

emphasized that the selection of activities for crashing should consider their impact on the entire critical path, as changes to one activity can trigger a chain effect that disrupts the stability of the project schedule.(Biswas et al. 2016).

To provide a visual representation of the impact of implementing an acceleration strategy, the Critical Path Method (CPM) was used to map the project's critical path before and after crashing. Figure 2 shows the critical path diagram before implementing the acceleration strategy, where this path consists of key structural activities with no float. Any delay in activities on this path will directly impact the total project duration.

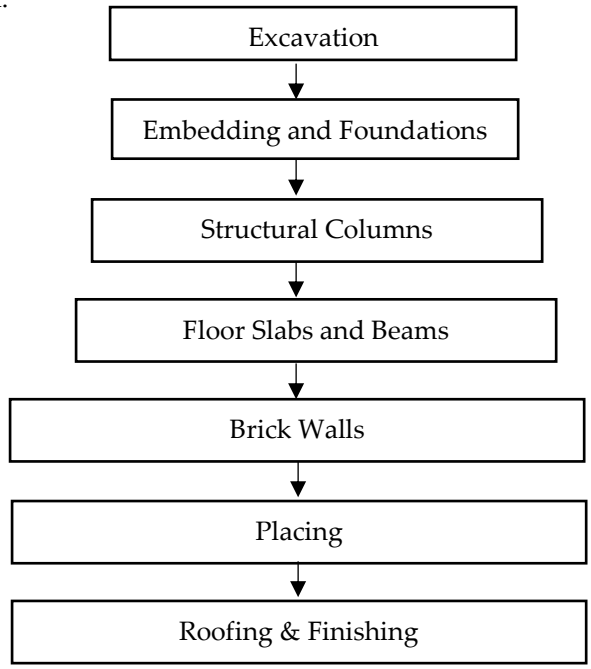

Figure 3. Critical Path Diagram Before Acceleration
(Total duration:214 days)

Furthermore, Figure 4 presents a critical path diagram after implementing an acceleration strategy through two approaches: increasing working hours (overtime) and increasing the workforce. The simulated critical path shows significant changes in activity duration, with time compression achieved without changing the dependency logic between activities.

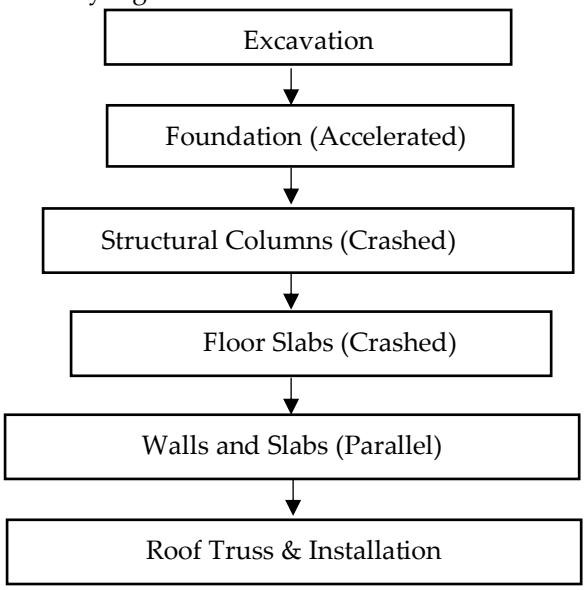

Figure 4. Critical Path Diagram After Acceleration
(Total duration:130 days)

The main change occurred in the duration of work on the critical path, which was successfully compressed without overhauling the logical flow of activities. Activities such as formwork, reinforcement, casting, and wall installation were accelerated through labor redistribution and overtime shift arrangements. Activities with previously zero float remained on the critical path, but their duration was significantly shortened.

This change demonstrated that activities could be compressed and executed in parallel without disrupting logical dependencies between tasks. Overall, the project duration was reduced from 214 days to 130 days, resulting in a time efficiency of 39.25%.

This finding is in line with the results of Galagali's (2017) research, which shows that optimal time efficiency in building projects through the Time-Cost-Quality Trade-Off (TCQTO) approach can reach the range of 30–40%, especially when the acceleration strategy is implemented selectively on critical path activities. The study also concluded that a combination of additional working hours (overtime) and additional labor can significantly reduce project duration without causing major deviations to the work network structure, as long as CPM-based planning is carefully implemented.

Table 3. Comparison of Project Acceleration Strategies from Managerial and Risk Aspects

Evaluation Aspects	Overtime Strategy	Employment Increase Strategy
Cost Efficiency (%)	0.38	0.16
Time Efficiency (%)	39.25	39.25
Risk of Fatigue	Tall	Low
Productivity Stability	Fluctuating (night hours)	Stable (normal hours)
Compatible for Narrow Areas	Yes	No
Human Resource Management Needs	Currently	Tall
Cost Sensitivity	High (overtime pay)	Low

Taking all these aspects into consideration, it can be concluded that the project acceleration strategy is not only determined by the amount of savings in duration and costs, but also by contextual factors such as work space, human resource capacity, and technical implementation risks. Therefore, strategy selection must be done holistically and based on data, so that project acceleration is not only effective numerically, but also safe and sustainable in implementation.

4. CONCLUSION

This study shows that the application of the Time Cost Trade-Off (TCTO) method based on the Critical Path Method (CPM) can significantly improve the efficiency of project duration without disrupting the dependency structure between activities. The two acceleration strategies tested, namely overtime and additional labor, successfully reduced the project duration from 214 days to 130 days, equivalent to a time efficiency of 39.25%. In terms of costs, overtime provides an efficiency of 0.38%, while additional labor produces 0.16%. Although the overtime strategy appears to be more efficient nominally, the results of sensitivity analysis and managerial considerations indicate that additional labor is more stable and feasible to implement, especially in medium-duration projects with adequate workspace. Visualization of the critical path before and after acceleration also confirms that key activities can be accelerated or run in parallel without causing structural deviations in the project network.

These findings align with the research of Galagali (2017), which demonstrated that a TCTO-based project acceleration strategy using the crashing method can be implemented selectively and effectively, taking into account activity characteristics, network structure, and field capacity. A CPM-based approach and optimal resource allocation are key to the success of realistically accelerating public construction projects. This study has limitations because the simulations were conducted under ideal

conditions. Field validation and dynamic simulations are recommended to improve the reliability of the results. Future research could integrate TCTO with artificial intelligence (AI) or multi-criteria optimization methods based on real-time data to produce more adaptive and contextual project acceleration decisions.

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