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Analysis of Project Time and Cost using the Crash Program Approach

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ABSTRACT

Project acceleration is a solution to speed up project completion. Project acceleration has various alternatives, including adding overtime hours and adding labor. This research aims to assess the changes in project time and costs following acceleration efforts through options such as increasing working hours (overtime) and adding labor. The project acceleration method used is the crash program method, supported by the Microsoft Project application. The research results show that for the option of adding overtime hours, with 1 hour of overtime, the cost was Rp 27,011,372,606.28 and the duration was 204.13 days; for 2 hours of overtime, the cost increased to Rp 27,156,499,375.32 with a duration of 199.01 days; with 3 hours of overtime, the cost was Rp 27,307,828,821.71 and the duration shortened to 194.62 days; and with 4 hours of overtime, the cost was Rp 27,465,750,984.13 with a duration of 190.92 days. For the alternative of adding labor, under a scenario equivalent to 1 hour of overtime, the cost was Rp 26,846,481,892.32 and the duration was 204.13 days; with 2 hours of overtime, the cost was Rp 26,797,919,204.37 with a duration of 199.01 days; with 3 hours of overtime, the cost decreased to Rp 26,746,499,142.20 and the duration was 194.62 days; and for 4 hours of overtime, the cost was Rp 26,703,236,580.04 with a duration of 190.92 days. Thus, adding labor is identified as an effective alternative due to its economical cost, even though it results in the same project acceleration duration.

Keywords: *Time, Cost, Crash Program, Microsoft Project.*

INTRODUCTION

Construction projects are currently on the rise, considering that construction projects play a vital role in realizing development in various fields. A construction project is an activity with a specific time frame and limited resources to carry out a predetermined task, such as building or repairing infrastructure (buildings, roads, bridges, dams), or conducting research and development activities [1].

The achievement of a project's success is often gauged by its ability to meet deadlines, maintain cost-efficiency, and deliver the intended quality. Effective construction project planning must prioritize identifying the optimal time frame and budget required for execution to ensure smooth operations. Challenges encountered during this process can impact the project's progress. Proper management of construction projects relies on expertise in coordinating the involved resources, which falls under the discipline of project management. This field encompasses the strategic planning, implementation, monitoring, and coordination of projects, spanning from conceptualization to completion, with the aim of delivering the project on schedule, within budgetary constraints, and in alignment with quality standards [2]. Thus,

project management serves as a key control tool in the planning phase, given that it deals with a variety of resources, such as timeline planning, budgeting, and managing labor and material needs. The objective of project management planning is to achieve the most efficient execution possible. While strong project management can significantly boost a company's profitability, rising project demands can pose challenges if the organization lacks robust management practices. As such, project management frameworks are essential for mitigating potential failures and risks [3]. Effective management focuses on core activities like scheduling and human resources coordination, which play a crucial role in ensuring precise budget estimations for the project's financial planning.

Time and cost are benchmarks for construction projects, where if the project costs increase, the time will also increase. With the extension of time, the project will experience delays, leading to penalties being imposed. These penalties are charged to the contractor, resulting in financial losses for the contractor [4]. The penalties are governed by Presidential Regulation No. 16 of 2018 of the Republic of Indonesia regarding Government Procurement of Goods and Services, Article 79, Paragraph (4), which explains that providers of goods/services who experience delays in completing the work within the timeframe stipulated in the contract due to the fault of the provider, will be subject to a delay penalty of 1/1000 (one per thousand) of the contract value or the value of the contract portion for each day of delay [5].

To address this issue, projects generally offer a solution by accelerating project completion to reduce the impact of increased time and costs that could negatively affect the project. The methods used to expedite project completion include the alternatives of increasing work hours (overtime) and adding more labors.

Referring to Government Regulation in Lieu of Law (Perpu) No. 2 of 2022 on Job Creation, Chapter IV, Article 77, Paragraph (2) elaborates that work hours surpassing 7 hours per day or 40 hours per week for a 6-day workweek, 8 hours per day or 40 hours per week for a 5-day workweek, as well as work conducted on designated weekly rest days and official public holidays, as determined by the government, are subject to regulation [6].

The meaning of the word 'overtime' refers to performing work duties outside of the established working hours, or in other words, working beyond regular hours to earn additional income [7].Overtime can be done by extending daily working hours without needing to add more labors. The purpose of adding work hours is to increase daily production so that work activities can be completed faster. However, it is important to consider the individual's daily work duration, as working too long can reduce productivity due to fatigue [8].

When adding labor, it is important to consider whether the workspace is too cramped or adequately spacious. The addition of labor for one activity should not disrupt the use of labor in other activities happening simultaneously. Additionally, proper supervision is necessary, as cramped workspaces and a lack of supervision can reduce worker productivity [8]

According to the Republic of Indonesia's Law No. 13 of 2003 on Manpower, Chapter I, Article 1, Paragraph (2) defines labor as any individual with the capacity to engage in productive activities, whether to generate goods or services, either for personal needs or for societal benefit. Additionally, Chapter I, Article 1, Paragraph (3) clarifies that the term 'workers' or 'laborers' refers to individuals who perform work in exchange for wages or other forms of compensation. [9].

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This study focuses on evaluating the time and cost elements of the Construction Project for the Laboratory Building and Lecture Hall of the PKK Department (FPP) at Universitas Negeri Padang, with the objective of reducing the project duration either to match the initial planned timeline or to complete it even sooner. The research employs a crash program method to achieve this acceleration, exploring two distinct strategies: extending working hours through overtime and increasing the workforce. Each strategy is assessed independently to understand their respective effectiveness, with the goal of identifying the most efficient approach. This effectiveness is measured by examining how significantly each alternative can reduce the project's duration either by realigning with the original schedule or by achieving a faster completion while simultaneously striving to maintain the most cost-efficient outcome.

METHOD

This research focuses on a case study of the Construction Project for the Laboratory Building and Lecture Rooms for the PKK Department (FPP) Universitas Negeri Padang. The study draws upon two types of data: primary data, which includes key project details such as the sequence of activities during execution and labor requirements, and secondary data, which comprises elements like the project timeline, budget plan, unit price analysis, material and labor costs, and weekly progress reports. The analysis and data processing were carried out using the crash program method, evaluating two distinct acceleration strategies extending working hours through overtime and increasing the number of laborers each analyzed independently.

Once all data has been gathered, the subsequent phase of the analysis involves organizing all work activities into a structured work network, known as network planning. Network planning serves as a strategic framework for guiding the completion of a project, comprising a sequence of interlinked tasks, each assigned a specific duration [10]. The formulation of this network is facilitated by the use of Microsoft Project, which aids in systematically arranging and visualizing the interconnected tasks to ensure a coherent project flow.

Microsoft Project

Microsoft Project is a software tool designed for effective project planning, management, tracking, and reporting of project related data [11]. It simplifies the process of identifying and organizing tasks within a network plan, making it easier to determine the critical path. By pinpointing this critical path, it becomes possible to identify key tasks that influence the project's timeline. Subsequently, selected tasks along this critical path are targeted for acceleration, helping to reduce the overall project duration and achieve faster completion.

Crash Program

The crash program is a strategy implemented to shorten the overall timeline of a project after evaluating various alternatives within the work network, aiming to optimize time efficiency [12]. This method is typically applied to activities that lie along the critical path. It offers multiple approaches for expediting the project, such as extending working hours through overtime or increasing the number of workers. The core concept of the crash program is to compress work durations by boosting productivity, enabling tasks to be completed more quickly than under normal productivity levels. However, it is essential to carefully manage this increased productivity, as pushing workers too hard can lead to fatigue, potentially resulting in a subsequent drop in productivity [8]. For evaluating the impact of additional working hours (overtime), the analysis employs the following formula:

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$$\text{Daily Productivity} = \frac{\text{Volume}}{\text{Duration (Normal)}} \quad (1)$$

$$\text{Productivity per Hour} = \frac{\text{Daily Productivity}}{\text{Working Hours per Day}} \quad (2)$$

$$\text{Crash Duration} = \frac{\text{Volume}}{(\text{Daily. Prod}) + \sum(a \times b \times \text{Prod. per Hour})} \quad (3)$$

Note:
a = Duration of overtime addition
b = Factor indicating the reduction in productivity associated with overtime work

The value representing the coefficient of decline in productivity is illustrated in the subsequent table.

Table 1. Coefficient of Decrease in Productivity

Extended hours	Decline in the Productivity Index	Work efficiency
1 Hour	0,1	90%
2 Hours	0,2	80%
3 Hours	0,3	70%
4 Hours	0,4	60%

$$\text{Usual Pay per Hour} = \frac{\text{unit price of worker wages}}{\text{Daily of Work}} \quad (4)$$

$$\text{compensation for additional hours worked beyond the standard work schedule} = (1{,}5 \times \text{Cost per Hour (Usual)}) + (2 \times (n \times \text{Cost per Hour (Usual)})) \quad (5)$$

Note:
n = Number of Additional Working Hours (Overtime)

$$\text{Cost Variance} = \text{Cost (Crash)} - \text{Cost (Normal)} \quad (6)$$

$$\text{Duration Variance} = \text{Duration (Crash)} - \text{Duration (Normal)} \quad (7)$$

$$\text{Cost Slope} = \frac{\text{Cost Variance}}{\text{Duration Variance}} \quad (8)$$

For the analysis of additional labor, the following formula is used:

$$\sum_{tkn} = \frac{\text{Coef. of Labor} \times \text{Volume}}{\text{Duration (Normal)}} \quad (9)$$

$$\sum_{tkc} = \frac{\text{Coef. of Labor} \times \text{Volume}}{\text{Duration (Crash)}} \quad (10)$$

$$\text{expenditure associated with the augmentation of the workforce} = \text{Total Count of Personnel Engaged in Work} \times \text{Daily Cost} \quad (11)$$

After obtaining the results of the time and cost analysis for both alternatives, the next step is to compile statistical data in the form of tables and graphs, which illustrate the changes in project time and cost after implementing the two alternatives. Below is the flow chart of this research.

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RESULTS AND DISCUSSION

Preparation of Work Network

Estimating the time required for each task is crucial to determining the duration needed to complete various components of a project. This process relies on several key data points, such as work volume, labor coefficients, and the project's budget plan. Work volume data specifies the amount of work to be done, while the labor coefficients are sourced from the guidelines provided in the Unit Price Analysis. The project's budget plan is typically provided by the contractor.

The calculation of the duration for each work item involves evaluating productivity rates, which then help establish the estimated time frame for completing each task. Effective execution of construction projects requires a diverse team, including a foreman, a chief carpenter, skilled laborers, and general workers.

Field observations reveal that skilled laborers are primarily responsible for tasks that align with their expertise, making their productivity a key factor in determining the project's completion. When developing the project's work breakdown structure, it is essential to consider task interdependencies, known as predecessors. The relationships between different work items are adjusted according to their respective start and end times. These interdependencies are determined based on logical sequencing, reflecting the real-time schedule as observed on-site. Subsequently, the coordination between various activities is systematically managed using Microsoft Project software, ensuring a well-organized workflow.

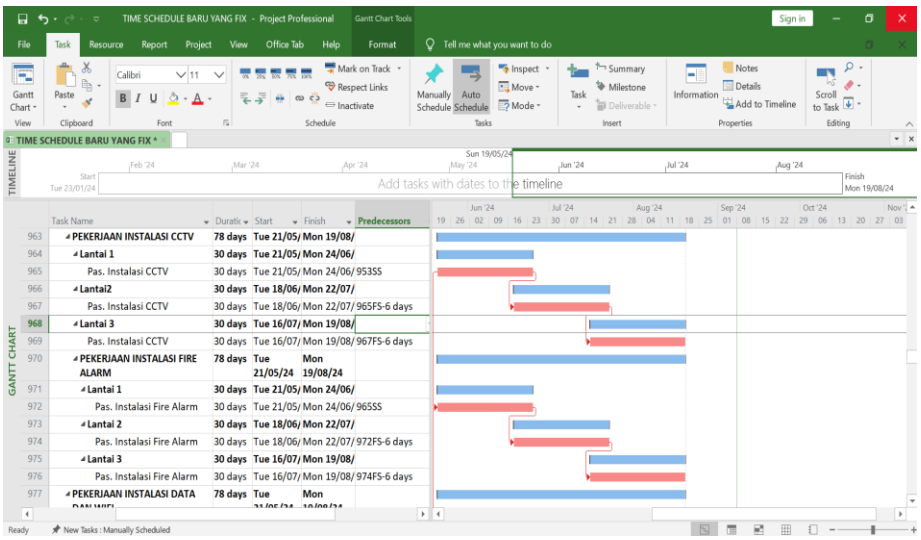

Figure 1. Network planning along with the critical path.

The determination of the critical path through the scheduling process in Microsoft Project highlights the activities most vulnerable to potential delays. This clarity enables a proactive approach to identifying solutions that can prevent these delays, ensuring the continuity and timely advancement of the project. By addressing these critical activities promptly, the project's overall momentum is maintained, minimizing risks to its successful completion.

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Table 2. List of critical activities.

Nu.	Code	Job Names	Duration (Days)
A		**Wall Work**	
1	PDB1	Wall Work ½ Brick Bond 1:2	48
2	PDB2	Wall Work ½ Brick Bond 1:4	48
B		**Floor Work**	
1	PGP	Installation of Polished Granite 60 x 60 cm	36
2	PGU	Installation of Unpolished Granite 60 x 60 cm	30
C		**Ceiling Work**	
1	PRPH	Installation of Hollow Ceiling Frame	36
D		**Plastering Work**	
1	PPDB1	Plastering Work for Brick Wall Bond 1:2	48
2	PPDB2	Plastering Work for Brick Wall Bond 1:4	48
E		**Grounding Work**	
1	PG	Installation of grounding panel with a maximum grounding resistance of 2 Ohm.	78
F		**CCTV Installation Work**	
1	PICCTV	Installation of CCTV	78
G		**Fire Alarm Installation Work**	
1	PIFA	Installation of Fire Alarm	78

Table 2 presents a compilation of critical activities chosen based on the data processing outcomes from Microsoft Project. These identified critical activities are slated for a thorough analysis of project acceleration. The table indicates that the task with the shortest completion time is the installation of unpolished granite tiles sized 60 x 60 cm, requiring a duration of 30 days. In contrast, the tasks with the longest durations involve the installation of grounding panels with a maximum resistance of 2 ohms, the setup of CCTV systems, and the implementation of fire alarm systems, each necessitating 78 days to complete.

Crash Program

Once the critical activities have been identified, the subsequent phase involves the execution of a crash program. The crash program method represents a strategy employed to expedite or diminish the duration of project implementation. The overall lifespan of the project is directly correlated with the time allocated to the critical path. The primary objective of accelerating task execution is to compress the critical path within the project's work network. Within the framework of the crash program method, various alternatives are considered, including extending work hours (overtime) by 1 to 4 hours and augmenting the labor force. These alternatives are then assessed against one another to ascertain which option proves to be the most effective for implementation.

Addition of Working Hours (Overtime)

Following an analysis of the project's timeline and costs for each variation pertaining to the alternative extension of work hours via overtime arrangements utilizing the crash program method, distinct differences in outcomes emerged for each incremental hour of overtime. The table presented below illustrates the analytical results concerning the project's duration and expenditures derived from the alternative approach of augmenting working hours through overtime.

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Table 3. Analysis Results of Project Time and Cost Using the Option of Extending Working Hours through Overtime Arrangements

No	Variation	Duration (Day)	Cost of Additional Working Hours (Overtime) (Day)	Cost Variance (Rp)	Duration Variance (Day)
	Normal	210			
1	1 Hour	209,60	Rp 26.927.000.000,00	Rp 84.372.606,28	5,87
2	2 Hours	208,73	Rp 27.011.372.606,28	Rp 229.499.375,32	10,99
3	3 Hours	207,86	Rp 27.156.499.375,32	Rp 380.828.821,71	15,38
4	4 Hours	207,00	Rp 27.307.828.821,71	Rp 538.750.984,13	19,08

Table 3 illustrates the alterations in project duration and costs resulting from the acceleration measures implemented through the alternative of extending working hours (overtime) via the crash program method. Under the scenario of 1 hour of overtime, the project duration is recorded at 204.13 days, reflecting a deviation of 5.87 days from the standard duration, with associated costs amounting to Rp 27,011,372,606.00. When 2 hours of overtime are applied, the duration decreases to 199.01 days, which is 10.99 days less than the normal duration of 210 days, and the total cost rises to Rp 27,156,499,375.00. In the case of 3 hours of overtime, the project duration is further reduced to 194.62 days, showing a difference of 12.84 days from the typical duration, and the costs escalate to Rp 27,307,828,822.00. Lastly, with 4 hours of overtime, the duration is minimized to 190.92 days, yielding a difference of 19.08 days from the normal duration of 210 days, resulting in a total cost of Rp 27,465,750,984.00.

Augmentation of the Workforce

The improvement of workforce capacity is realized by converting each additional hour of overtime into its corresponding value regarding the number of workers involved. Following an analysis of the project's time and cost for each variant concerning the alternative increase in labor through the crash program method, distinct equivalent outcomes were identified for each variation of overtime hours. The subsequent table showcases the analytical findings related to project duration and costs under the alternative strategy of augmenting labor resources.

Table 4. Analysis Results of Project Time and Cost Using the Alternative of Adding Labor

No	Variation	Duration (Day)	Cost of Additional of Labor (Day)	Cost Variance (Rp)	Duration Variance (Day)
	Normal	210			
1	1 Hour	209,60	Rp 26.846.481.892,32	-Rp 80.518.107,68	5,87
2	2 Hours	208,73	Rp 26.797.919.204,37	-Rp 129.080.795,63	10,99
3	3 Hours	207,86	Rp 26.746.499.142,20	-Rp 180.500.857,80	15,38
4	4 Hours	207,00	Rp 26.703.236.580,04	-Rp 223.763.419,96	19,08

Table 4 illustrates the modifications in project duration and costs following the implementation of project acceleration through the strategy of enhancing the workforce. For the scenario corresponding to 1 hour of overtime, the project duration is recorded at 204.13 days, reflecting a variance of 5.87 days from the standard duration, with associated costs amounting to Rp 26,840,818,007.00. In the scenario equivalent to 2 hours of overtime, the duration decreases to 199.01 days, which signifies a difference of 10.99 days from the normal duration of 210 days, incurring costs of Rp 26,787,797,933.00. When examining the condition representing 3 hours

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of overtime, the duration further shortens to 194.62 days, with a deviation of 12.84 days from the typical timeline, and expenses totaling Rp 26,731,670,395.00. Finally, for the condition reflecting 4 hours of overtime, the project duration is 190.92 days, indicating a reduction of 19.08 days from the normal duration of 210 days, with costs amounting to Rp 26,703,236,580.04.

Following the acquisition of the project time and cost analysis results with the aforementioned two alternatives utilizing the crash program method, a comparative evaluation of these alternatives is conducted. The results of this comparison are depicted in graphical form.

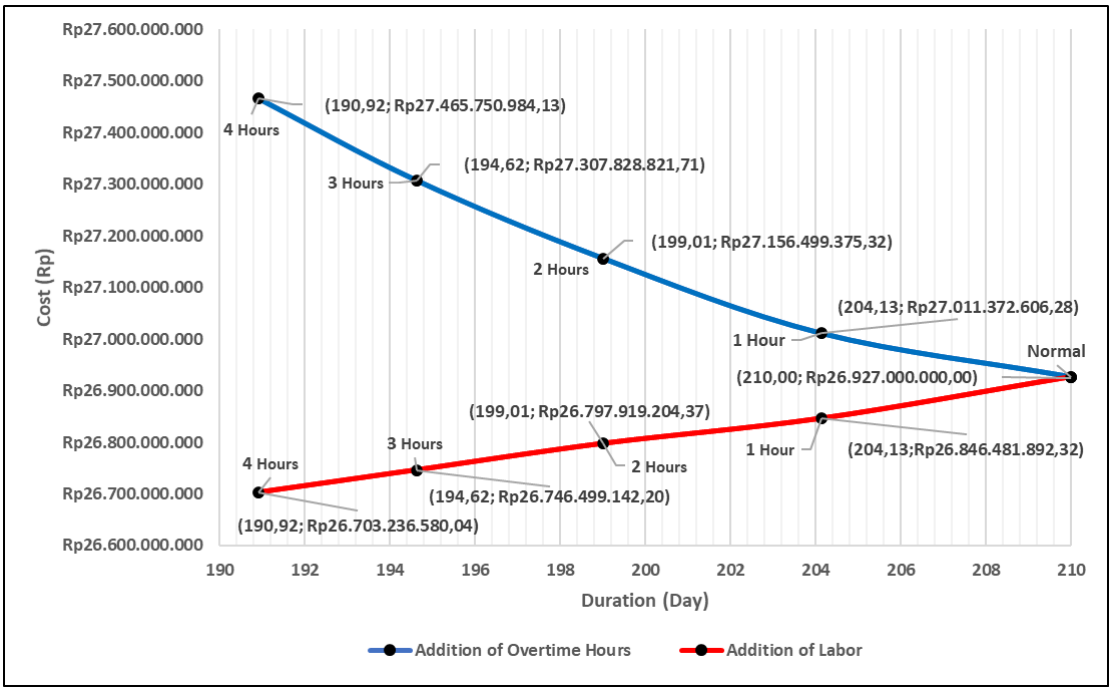

Figure 2. Graphical Representation Comparing the Option of Extending Working Hours through Overtime with the Alternative of Increasing the Workforce

Figure 2 presents a comparative analysis between the alternatives of extending working hours (overtime) and augmenting the workforce. The graph representing the overtime alternative illustrates a rising trend in costs corresponding to each variation in overtime hours, peaking at Rp 27,465,750,984.00 for a duration of 190.92 days. Conversely, the graph reflecting the alternative of increasing the workforce demonstrates a reduction in costs associated with each equivalent variation of overtime hours, culminating in a maximum expenditure of Rp 26,703,236,580.04, also with a duration of 190.92 days.

CONCLUSION

The findings and discussions reveal significant alterations in project duration and costs following the implementation of various alternatives through the crash program method for project acceleration. Specifically, when utilizing the alternative of extending working hours (overtime) under maximum conditions (4 hours of overtime), the total cost amounts to Rp 27,465,750,984.13, accompanied by a duration of 190.92 days. In contrast, the alternative of increasing labor, under equivalent maximum conditions (4 hours of overtime), results in a reduced expenditure of Rp 26,703,236,580.04, while also maintaining a duration of 190.92 days.

Upon analyzing the changes in project time and costs as a result of implementing both alternatives via the crash program method, a conclusion was drawn regarding the effectiveness of each approach in terms of time and cost efficiency, ultimately determining which alternative is more advantageous for the project. The addition of labor emerged as the more effective alternative, offering more economical costs, even though both options achieved the same duration of project acceleration. Nevertheless, it is crucial to consider the specific scope of the project when opting for the labor addition alternative. In projects with limited scope, careful evaluation is essential due to the restricted space available for workers, which could lead to discomfort and a subsequent decline in productivity. Based on the conducted research, future studies might explore alternative strategies, such as implementing a work shift system, to further minimize cost overruns during the acceleration analysis.

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