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# STRATEGIC OVERTIME IMPLEMENTATION: ASSESSING CRASH TIME, CRASH COST AND COST SLOPE IN THE CONSTRUCTION OF KADIRI UNIVERSITY'S 4-STORY BUILDING

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**Abstract:** The lecture building is an important building which is the center of academic activities where educational activities are carried out. Currently, the construction of a four-story lecture building at Kadiri University is experiencing significant project delays with a deviation of 5.64% from the plan. Crash analysis can be carried out to speed up the duration of the project so that it can be completed on time with additional working hours. This research aims to determine crash time, crash costs, and cost slope for the application of overtime on the 4-story building construction project at Kadiri University. A quantitative and case study approach was used with data collected through observation, interviews, and analysis of project documents. Critical Path Method (CPM) analysis is carried out using Microsoft Project software to identify work that is on the critical path. Crashing is done by calculating crash time, crash cost, and cost slope. The research results show that applying 1 hour of overtime can speed up the project by 12 working days, with an additional cost of IDR 24,488,758. Cost slope analysis shows additional overtime costs of IDR 12,244,379. This research shows that the application of measurable overtime and crashing analysis can effectively overcome project delays in the context of building educational facilities.

**Keywords**: Project Delays, Crashing, Overtime, Project management.

## INTRODUCTION

As one of the main facilities in higher education institutions, lecture buildings function as centers of academic activity where the teaching and learning process takes place. This building provides a conducive space for students and lecturers to interact, exchange ideas, and carry out various academic activities such as lectures, seminars and group discussions [1]. Apart from that, adequate facilities in lecture buildings, such as comfortable classrooms, complete laboratories, and representative discussion areas, really support the effectiveness of the learning and research process. Good lecture buildings not only play a role in supporting academic activities, but also in improving the quality of education and research at a university. At Kadiri University, the construction of a 4-story lecture building is a strategic step to accommodate the growth in student numbers and meet the need for adequate educational facilities. This building is designed to provide an optimal learning environment with various modern facilities that support the academic process. The existence of representative lecture buildings is also an attraction for prospective students and lecturers, so that it can improve the university's reputation at the national and international level [2]. In addition, effective time and cost management in the construction of this building is essential to ensure the project is completed on time and within budget, without compromising construction quality.

However, in its implementation, the construction of the Kadiri University lecture building faced significant challenges related to project delays. This project is planned to be completed within 43 weeks, starting in October 2023 to August 2024, with a budget of IDR 20,551,534,000. Even though planning has been carried out carefully, the latest report shows that there are deviations in project progress. In the 25th week, the project should have achieved progress of 53.59%. However, realization in the field shows that project progress has only reached 47.95%. This indicates a delay with a deviation of 5.64%. This delay raises concerns about the project's ability to be completed on time and within the allocated budget. The delay in this project cannot be separated from several influencing factors. One factor is the delay in the process of casting the building structure. Structural casting is a crucial stage in building construction, and delays in this process can cause significant delays in the overall project schedule [3]. This 5.64% delay, if not addressed immediately, could result in increased costs and further delays. Therefore, an in-depth analysis of the causes of delays and the implementation of effective strategies to overcome them is needed. Thus, the project can return to the planned track and ensure timely completion in accordance with the contract [4].

To overcome delays in the construction of Kadiri University lecture buildings, one strategy that can be implemented is to increase working hours through overtime. Overtime can be an effective solution to catch up on delays and ensure projects can be completed on schedule [5]. By increasing working hours outside regular working hours, delayed work can be completed more quickly so that project progress can return to according to the initial plan [6]. However, the application of overtime must be carried out carefully and in a measured manner so as not to cause an uncontrolled increase in costs. Overtime analysis needs to consider various factors such as the number of workers required, the duration of overtime, and the overtime wages that must be paid [7]. Even though overtime can be an effective solution to overcome delays, its implementation must be done with appropriate calculations so as not to result in costs that are greater than the predetermined budget [8]. Uncontrolled overtime costs can increase the financial burden of a project and even disrupt budget allocations for other needs. Therefore, it is necessary to carry out an in-depth analysis to determine the optimal amount of overtime so that we can catch up without spending excessive costs [9]. In this way, lecture building construction projects can be completed on time and within budget, without sacrificing construction quality.

One analysis method that can be applied to overcome project delays and analyze overtime time and costs is crashing. Crash analysis can be used to calculate crash time, crash cost, and cost slope [10]. Crash time is the shortest time required to complete an activity with additional working hours, while crash cost is the additional cost required to achieve that crash time. Cost slope is calculated by dividing the difference between crash cost and normal cost by the difference between normal time and crash time. This analysis helps in determining which activities should be increased and what additional costs are needed to speed up project completion [11]. By conducting a crashing analysis, the project team can identify activities that have a significant impact on the overall duration of the project and determine the most efficient actions to reduce completion time [12]. This allows project management to make data-driven decisions regarding additional overtime or other resources by considering the costs and benefits. An effective crashing strategy can help catch up on delays without compromising project quality or exceeding the established budget. Therefore, applying crashing analysis in the Kadiri University lecture building construction project is very important to ensure the project is completed on time, within budget, and meets the expected quality standards.

Previous research has examined the application of the Crashing method in an effort to speed up construction project completion by reducing the duration of critical activities. A study by [13] evaluated the Stroke Center Building construction project using the Crashing method and found that adding overtime working hours was more economical than adding labor, although there was still an increase in overall costs. This research emphasizes the importance of evaluating costs and time simultaneously in managing construction projects. Furthermore, research by [14] on a road improvement project in Tegal shows that implementing Crashing can reduce the project duration from 45 days to 39 days with significant additional costs. Although the increase is less significant in terms of costs, this research shows the importance of time management strategies to reduce project delay deviations. Research [15] on the Kutisari 2 Elementary School construction project also shows that implementing Crashing can speed up project completion with additional costs that must be incurred. In this research, the initial project cost was Rp. 1,164,171,924 increased to Rp. 1,638,741,704 after crashing. Other research by [16] on the Pulomas LRT project emphasizes that adding overtime working hours without increasing labor can reduce the project duration from 90 days to 67 days at an additional cost of Rp. 118,550,000. These findings underscore the importance of careful calculations in implementing Crashing to ensure that project acceleration does not result in excessive cost increases.

However, there is a gap in existing research regarding the integration between Crashing analysis and the application of overtime, especially in the context of educational facility construction projects such as lecture buildings. The novelty of this research lies in the combination of these two strategies to optimize time and costs simultaneously. This research aims to determine crash time, crash costs, and cost slope for the application of overtime on the 4-story building construction project at Kadiri University. Thus, it is hoped that this research can make a new contribution to construction project management, especially in the context of building educational facilities, and provide practical guidance for project managers in overcoming delays with efficient and effective strategies.

## RESEARCH METHOD

This research uses a quantitative approach to analyze the effectiveness of applying the Crashing and overtime method in overcoming delays in the four-story lecture building construction project at Kadiri University. This research is designed as a case study that aims to evaluate the implementation of project management strategies in a real context. The data collected includes primary and secondary data. Primary data was obtained through direct observation at the project site and interviews with the project manager. Meanwhile, secondary data includes project documents such as the Cost Budget Plan (RAB), project schedule, and available project progress reports. In this research, data analysis was carried out using Microsoft Project software to identify critical paths and calculate crash time, crash cost and cost slope. The analysis process begins by determining the activities that are on the critical path using the Critical Path Method (CPM).

### CPM Analysis

Critical Path Method (CPM) analysis is an important step in this research to identify activities that are on the critical path of the Kadiri University lecture building construction project. The first step in CPM analysis is to collect data regarding the duration of each activity, dependencies between activities, and the logical sequence of activity implementation. This data is obtained from project documents such as project schedules and progress reports. After the data is collected, the next step is to map all project activities into a network diagram using Microsoft Project software. This network diagram will help in identifying the critical path, which is a series of activities that determine the overall duration of the project. Activities on the critical path do not have slack time so that any delays in these activities will directly affect the project completion time. In this process, Microsoft Project software will be used to calculate the earliest start time (ES), the earliest finish time (EF), the latest finish time (LF), and the latest start time. (Latest Start - LS) for each activity. These values are then used to determine which activities are included in the critical path.

### Crashing Analysis

After carrying out a Critical Path Method (CPM) analysis to identify critical activities in the Kadiri University lecture building construction project, the next step is to apply Crashing analysis to speed up project completion. Crashing analysis is carried out with the aim of reducing project duration by adding work hours to critical activities that have been previously identified. The first step in Crashing analysis is to determine the most efficient critical activities to accelerate. For each critical activity, it is necessary to calculate crash time (acceleration time), namely the shortest time that can be achieved by increasing working hours or overtime. Apart from that, crash costs (acceleration costs) are also calculated, namely the additional costs required to achieve the crash time. This data collection involves estimating the additional costs associated with additional work hours. After crash time and crash costs are calculated, the next step is to calculate the cost slope for each critical activity. Cost slope is calculated using the formula:

$$Cost\ Slope = \frac{Crash\ Cost - Normal\ Cost}{Normal\ Time - Crash\ Time}$$

This cost slope shows the additional cost per unit of acceleration time and is used to determine which activities are most efficient to accelerate. Activities with the lowest cost slope are usually prioritized for acceleration because they provide the greatest time acceleration with the smallest additional costs.

## RESULT AND DISCUSSION

### Critical Task

The critical path has been identified using data entered into Microsoft Project. This path includes a series of jobs that have direct dependencies and have a direct impact on the total duration of the project. The results of the critical path analysis are shown in Table 1.

**Table 1.** Critical Path Analysis Results

| Work Name | Slack |
|---|---|
| Site Cleaning Work | 0 |
| Demolition | 0 |
| Temporary Project Fence | 0 |
| Preparation of RK3K, Employment Insurance and Licensing | 0 |
| Provision of Job Protection Equipment | 0 |
| Provision of Personal Protective Equipment | 0 |
| Heavy Equipment Work | 0 |

| Work Name | Slack |
|---|---|
| Geotechnical Work | 0 |
| Pilecap Foundation Work | 0 |
| Pile Foundation Work | 0 |
| 1st Floor Structural Column Work | 0 |
| 1st Floor Structural Beam Work | 0 |
| 2nd Floor Structural Column Work | 0 |
| 2nd Floor Structural Beam Work | 0 |
| 3rd Floor Structural Column Work | 0 |
| 3rd Floor Structural Beam Work | 0 |
| 4th Floor Structural Column Work | 0 |
| 4th Floor Structural Beam Work | 0 |
| 5th Floor Structural Column Work | 0 |
| Floor Beam and Floor Plate Work on Floor 5 | 0 |
| 5th Floor Masonry and Plastering Work | 0 |
| 5th Floor Floor and Wall Coating Work | 0 |
| 5th Floor Painting Work | 0 |
| Roof Floor Clean Water Installation Work | 0 |
| Roof Floor Rainwater Installation Work | 0 |

Based on the results of critical path analysis using Microsoft Project which is shown in the critical path path obtained, namely for Site Cleaning Work, Demolition, Temporary Project Fencing, RK3K Preparation, Employment Insurance and Licensing, Provision of Work Protection Equipment, Provision of Personal Protective Equipment, Heavy Equipment Work, Work Soil, Pilecap Foundation Work, Pile Foundation Work, 1st Floor Structural Column Work, 1st Floor Structural Beam Work, 2nd Floor Structural Column Work, 2nd Floor Structural Beam Work, 3rd Floor Structural Column Work, 3rd Floor Structural Beam Work, Floor Structure Column Work 4, 4th Floor Structural Beam Work, 5th Floor Structural Column Work, 5th Floor Floor Beam and Plate Plate Work, 5th Floor Masonry and Plastering Work, 5th Floor Floor and Wall Coating Work, 5th Floor Painting Work, Roof Floor Clean Water Installation Work, and Roof Floor Rainwater Installation Work.

**Crashing**

Project acceleration is carried out by adding working hours (overtime) to the activities on the critical path. Apart from that, worker productivity is also taken into consideration when working additional hours. Worker productivity in overtime hours decreases as working hours increase. The reduction is 90% for 1 hour of overtime (Sugiyanto, 2020). Crash time analysis is only carried out for 1 hour of overtime. This is because the more overtime hours implemented will reduce the value of worker productivity. This decrease in productivity is caused by various factors such as fatigue and decreased quality of vision, especially at night. Crash time is only carried out on work that is on the critical path and has not yet been completed when a delay is identified. The crash time results are shown in Table 2.

**Table 2.** Crash Time Results

| Activity | Normal Time (Working Days) | Volume | Productivity | Crash Time (Working Days) | Selisih (Working Days) |
|---|---|---|---|---|---|
| **3rd FLOOR STRUCTURAL WORK** | | | | | |
| 3rd Floor Structural Beam Work | 18 | 105.36 | 0.732 | 16 | 2 |
| Structural Beam B2 measures 45cm x 80cm | | 88.38 | | | |
| Structural Beam B3 measures 30cm x 50cm | | 16.43 | | | |
| Structural Beam B4 measures 20cm x 40cm | | 0.55 | | | |
| **4th FLOOR STRUCTURAL WORK** | | | | | |
| 4th Floor Structural Column Work | 24 | 65.22 | 0.340 | 22 | 3 |
| Practical Column measuring 10cm x 10cm | | 1.68 | | | |
| Column Structure K1 measures 85cm x 85cm | | 26.01 | | | |
| Column Structure K2 measures 90cm x 90cm | | 32.40 | | | |
| Column Structure K4 measures 45cm x 45cm | | 0.81 | | | |

| Activity | Normal Time (Working Days) | Volume | Productivity | Crash Time (Working Days) | Selisih (Working Days) |
|---|---|---|---|---|---|
| Column Structure K5 measures 30cm x 60cm | | 4.32 | | | |
| 4th Floor Structural Beam Work | 24 | 105.36 | 0.549 | 22 | 3 |
| Structural Beam B2 measures 45cm x 80cm | | 88.38 | | | |
| Structural Beam B3 measures 30cm x 50cm | | 16.43 | | | |
| Structural Beam B4 measures 20cm x 40cm | | 0.55 | | | |
| **5th FLOOR STRUCTURAL WORK** | | | | | |
| 5th Beam and Floor Plate Work | 18 | 77.69 | 0.540 | 16 | 2 |
| Floor beams measuring 10cm x 15cm | | 0.43 | | | |
| Concrete 5th Floor Plate with a thickness of 12cm | | 77.26 | | | |
| **ARCHITECTURAL WORK** | | | | | |
| **5TH FLOOR ARCHITECTURAL WORK** | | | | | |
| 5th Floor Masonry and Plastering Work | 18 | 2647.40 | 18.385 | 16 | 2 |
| Lightweight Bricks 10cm thick | | 290.60 | | | |
| Plastering Work with Mortar | | 1178.40 | | | |
| Acian Mortar Work | | 1178.40 | | | |
| Total | | | | | 12 |

The crash time results show that the project can be accelerated by 12 working days through additional working hours or overtime by 1 hour. This is in accordance with project delays where based on the S curve the project is experiencing a delay of 2 weeks.

In increasing workers' overtime hours, there are government regulations that must be followed by contractors. The regulations that must be followed are the decree of the Minister of Manpower Number KEP.102/MEN/VI/2004 article 3 and article 11 concerning working time and wage standards. The regulation states that overtime work can only be done for a maximum of 3 (three) hours in 1 (one) day and 14 (fourteen) hours in 1 (one) week. Apart from that, the way to calculate overtime wages is that for the first hour of overtime work you must be paid a wage of 1.5 (one and a half) times the hourly wage. Referring to these regulations, the wages for workers on the Kadiri University 4-story building construction project are as follows

Hourly Workers' Wages = Workers' Wages Per Day / Hours Worked
= 85,000 / 8
= Rp. 10,625.00

1 Hour Overtime Cost = Hourly Worker Wage x 1.5
= 10.625 x 1.5
= Rp. 15,937.00

Based on the results of the analysis, overtime costs for an additional 1 hour of overtime are IDR. 15,937.00/hour. After the overtime costs per hour are obtained, the crash cost and cost slope values can be calculated as shown in Table 3.

Table 3. Crash Cost and Cost Slope Results

| Activity | Normal Cost | Crash Cost | Difference | Cost Slope |
|---|---|---|---|---|
| **3rd FLOOR STRUCTURAL WORK** | | | | |
| 3rd Floor Structural Beam Work | Rp 68,850,000.00 | Rp 72,674,640.00 | Rp 3,824,640.00 | Rp 1,912,320.00 |
| Structural Beam B2 measures 45cm x 80cm | Rp 48,960,000.00 | Rp 51,679,744.00 | Rp 2,719,744.00 | Rp 1,359,872.00 |
| Structural Beam B3 measures 30cm x 50cm | Rp 15,300,000.00 | Rp 16,149,920.00 | Rp 849,920.00 | Rp 424,960.00 |
| Structural Beam B4 measures 20cm x 40cm | Rp 4,590,000.00 | Rp 4,844,976.00 | Rp 254,976.00 | Rp 127,488.00 |
| **4th FLOOR STRUCTURAL WORK** | | | | |
| 4th Floor Structural Column Work | Rp 57,120,000.00 | Rp 62,177,192.00 | Rp 5,057,192.00 | Rp 2,528,596.00 |

| Activity | Normal Cost | Crash Cost | Difference | Cost Slope |
|---|---|---|---|---|
| Practical Column measuring 10cm x 10cm | Rp 8,160,000.00 | Rp 8,882,456.00 | Rp 722,456.00 | Rp 361,228.00 |
| Column Structure K1 measures 85cm x 85cm | Rp 16,320,000.00 | Rp 17,764,912.00 | Rp 1,444,912.00 | Rp 722,456.00 |
| Column Structure K2 measures 90cm x 90cm | Rp 18,360,000.00 | Rp 19,985,526.00 | Rp 1,625,526.00 | Rp 812,763.00 |
| Column Structure K4 measures 45cm x 45cm | Rp 6,120,000.00 | Rp 6,661,842.00 | Rp 541,842.00 | Rp 270,921.00 |
| Column Structure K5 measures 30cm x 60cm | Rp 8,160,000.00 | Rp 8,882,456.00 | Rp 722,456.00 | Rp 361,228.00 |
| 4th Floor Structural Beam Work | Rp 91,800,000.00 | Rp 99,927,630.00 | Rp 8,127,630.00 | Rp 4,063,815.00 |
| Structural Beam B2 measures 45cm x 80cm | Rp 65,280,000.00 | Rp 71,059,648.00 | Rp 5,779,648.00 | Rp 2,889,824.00 |
| Structural Beam B3 measures 30cm x 50cm | Rp 20,400,000.00 | Rp 22,206,140.00 | Rp 1,806,140.00 | Rp 903,070.00 |
| Structural Beam B4 measures 20cm x 40cm | Rp 6,120,000.00 | Rp 6,661,842.00 | Rp 541,842.00 | Rp 270,921.00 |
| **5th FLOOR STRUCTURAL WORK** | | | | |
| 5th Beam and Floor Plate Work | Rp 91,800,000.00 | Rp 96,899,520.00 | Rp 5,099,520.00 | Rp 2,549,760.00 |
| Floor beams measuring 10cm x 15cm | Rp 12,240,000.00 | Rp 12,919,936.00 | Rp 679,936.00 | Rp 339,968.00 |
| Concrete 5th Floor Plate with a thickness of 12cm | Rp 79,560,000.00 | Rp 83,979,584.00 | Rp 4,419,584.00 | Rp 2,209,792.00 |
| **ARCHITECTURAL WORK** | | | | |
| **5TH FLOOR ARCHITECTURAL WORK** | | | | |
| 5th Floor Masonry and Plastering Work | Rp 42,840,000.00 | Rp 45,219,776.00 | Rp 2,379,776.00 | Rp 1,189,888.00 |
| Lightweight Bricks 10cm thick | Rp 12,240,000.00 | Rp 12,919,936.00 | Rp 679,936.00 | Rp 339,968.00 |
| Plastering Work with Mortar | Rp 15,300,000.00 | Rp 16,149,920.00 | Rp 849,920.00 | Rp 424,960.00 |
| Acian Mortar Work | Rp 15,300,000.00 | Rp 16,149,920.00 | Rp 849,920.00 | Rp 424,960.00 |
| TOTAL | Rp 352,410,000.00 | Rp 376,898,758.00 | Rp 24,488,758.00 | Rp 12,244,379.00 |

The strategy of implementing 1 hour of overtime is applied to several jobs that are on the critical path for 3rd Floor Structural Beam Work, 4th Floor Structural Column Work, 4th Floor Structural Beam Work, 5th Floor Beam and Floor Plate Work, and 5th Floor Masonry and Plastering Work .

The crash cost results show that there was an increase in costs due to the implementation of 1 hour of overtime. The increase was 6.95%. Meanwhile, the difference between normal cost and crash cost is obtained at a cost of Rp. 24,488,758.00 These costs are additional costs that must be incurred due to the implementation of 1 hour of overtime. Apart from that, the results of the cost slope analysis show that the additional 1 hour of overtime has a value of Rp. 12,244,379.00.

## CONCLUSION

Based on the research results, it was found that project acceleration was carried out by increasing working hours or overtime by 1 hour. The crash time results show that the project can be accelerated by 12 working days or 2 weeks. The results of the crash cost analysis were obtained at Rp. 376,898,758.00 with an increase of 6.95% from normal cost. The difference between normal costs and crash costs is IDR. 24,488,758.00 These costs are additional costs that must be incurred due to the implementation of 1 hour of overtime. Apart from that, the results of the cost slope analysis show that the additional 1 hour of overtime has a value of Rp. 12,244,379.00. This research makes an important contribution to construction project management by showing that the application of measurable overtime and crashing analysis can effectively overcome project delays. The results of this research can also be used as a reference for project managers in designing efficient and optimal acceleration strategies for similar projects in the future.

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