

Time Cost Trade Off (TCTO) Analysis by Considering Overtime Working Hours, and Labor Factors on the Outer East Ring Road (OERR) Surabaya Project (STA 0+000 – STA 5+875)

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ARTICLE INFO	ABSTRACT
<p>Article Information</p> <p>Article Received: 2022-08-04 Article Revised: 2022-10-21 Article Accepted:</p>	<p>In the implementation of construction projects, unwanted things often occur, including delays. Several factors cause these delays: inadequate material stock, delays in material arrival, damage to some tools, and human resources. Thus, it can affect the cost budget incurred to be bloated or excessive compared to the planned cost budget. In this study, an acceleration analysis was carried out on the Outer East Ring Road (OERR) Surabaya project using the Time Cost Trade Off (TCTO) method. Based on field conditions, the alternative to be used was to increase overtime working hours and increase the number of laborers. After the acceleration analysis, it was obtained that the acceleration alternative with the additional working hours (overtime) obtained an acceleration time of 224 days, with a total cost of IDR 95.435.963.465 from the normal cost of IDR 92.207.904.586. It was obtained that the acceleration alternative using additional working hours (overtime) generated a time efficiency of 17.04%, while cost efficiency decreased by 0.01%. While for the alternative of additional labor, the acceleration time was 130 days, with a total cost of IDR 95.438.444.127 from the normal cost of IDR 92.207.904.586. It was obtained that the acceleration alternative using additional working hours (overtime) generated a time efficiency of 51.85%, while cost efficiency decreased by 0.02%.</p>
<p>Keywords</p> <p><i>Time Cost Trade Off (TCTO), Time acceleration, Duration, Cost.</i></p>	

INTRODUCTION

Working on a project requires good and careful planning and implementation because it requires a clear and efficient cost budget calculation and implementation method. It is conducted to make project implementation completed according to plan in terms of time and cost.

In the implementation of construction projects, undesirable things often occur, including delays. In the implementation of construction projects, unwanted things often occur, including delays. Several factors cause these delays: inadequate material stock, delays in material arrival, damage to some tools, and human resources.

This study analyzed the acceleration of the construction project implementation experiencing delays. This study used a case study from the Outer East Ring Road (OERR) Surabaya project. It is one of the Surabaya City Government's development plans implemented in 2019. This road construction aimed to overcome the congestion during peak hours due to the increasing volume of vehicles on the Middle East Ring

Road (MERR) [1].

The project acceleration analysis in this study was carried out to avoid losses on the contractor side and the project owner to avoid delays. The method used to overcome the delay was the Time Cost Trade Off (TCTO) method. It aimed to shorten the project completion time while considering the minimum possible cost. Acceleration was conducted by compressing the work network. One of them used the additional overtime working hours and labor or a combination of these two.

The acceleration alternative used in this study was to use alternatives with additional overtime working hours and additional labor, where if the number of labor increases, several work items need to increase the number of heavy equipment. However, this study did not increase the number of heavy equipment because field conditions were not possible.

With this time acceleration analysis on the construction of the Outer East Ring Road (OERR), it is expected to be able to produce a duration that is according to the optimum cost and can choose the right solution if there is a delay in project implementation.

LITERATURE REVIEW

A. General Description

According to [2], Project Management is the application of science, expertise, and skills, the best technical means and with limited resources, to achieve predetermined goals and objectives to obtain optimal results in terms of cost, quality and time performance, and work safety. Project Management is all the planning, implementation, control, and coordination of a project from the beginning (idea) to the end to ensure the project's implementation on time, at the right cost, and at the right quality [3].

Project management has the following objectives [4]:

1. For all these series of activities to be on time, in this case, there is no delay in project completion.
2. Appropriate costs, mean that there are no additional costs outside of the planned costs.
3. Quality conforms to requirements.
4. Process activities conforms to requirements.

B. Project Scheduling

Scheduling is a scale of thinking deeply through issues, examining logical paths, arranging various tasks, resulting in a complete activity, and writing down various activities in a logical framework and time sequence [5].

Project activities are usually organized in the form of a diagram, namely Network Diagram (Network Planning). In this Network Planning, several paths will be seen, including critical paths that are used to accelerate the time on the project.

C. Time Cost Trade Off (TCTO) Analysis

According to the definition of TCTO, it is a deliberate, systematic, and analytical process by testing all activities in a project centered on activities on the critical path.

According to [6], Time Cost Trade Off is a schedule compression to gain benefits in terms of time (duration), cost, and revenue. It aims to compress the acceptable project duration to minimize the total project costs. The duration reduction is done by selecting certain activities with critical paths with cost slopes.

While according to [7], Time Cost Trade Off (TCTO) or also called *Pertukaran Waktu dan Biaya* aims to accelerate the project implementation time (Duration) in completing a project by compressing the activity durations to get the fastest completion time at the optimum cost. Cost control carried out is the direct cost because this cost will increase if a duration reduction is conducted. This compression is conducted on activities on the critical path with the lowest cost slope.

D. Crashing Scenario

In a project that is desired to be completed within a predetermined period, it is possible to accelerate the activity duration with the consequence that there will be an increase in costs. Acceleration of the project implementation duration at the lowest possible cost is called Project Crashing [8].

E. Productivity

After knowing how to do crashing, the next step is productivity calculation. Productivity is a concept that

shows the relationship between work results and the unit of time required to produce labor productivity. As in journal [9].

F. Time and Cost Relationship

In the construction project implementation, Cost and Time have a close relationship. Obtaining optimal cost requires the minimum total cost of the project, which is highly dependent on the duration of the project completion, both can change according to the progress of the project.

To analyze the relationship between cost and time of an activity according to the statement [10], several terms are used, namely as follows:

1. Normal Duration (ND)

Normal duration is the period required to complete the work until it is completed normally.

2. Crash Duration (CD)

Crash duration or shortened time is the shortest time to complete a work that is technically possible to accelerate.

3. Normal Cost (NC)

Normal cost is the cost required to complete the work within a normal period. The stages are as follows:

a. Normal Cost of Labor per Hour

= unit cost of work x productivity per hour

b. Normal Cost of Labor per Hour

= normal working hours x normal cost per hour

c. Normal Cost

= normal duration x normal cost work per day

4. Crash Cost (CC)

Crash Cost or cost for shortened time is the amount of labor costs/wages required to complete work with an accelerated period (Crash Duration). Based on the Decree of the Minister of Manpower and Transmigration of the Republic of Indonesia Number KEP. 102/MEN/VI/2004 concerning varies of overtime working wages. For the first overtime working hours, a wage of 1.5 (one and a half) times the hourly wage shall be paid, and for each subsequent overtime working hour, a wage of 2 (two) times the hourly wage shall be paid. The following is the formula for Crash Cost calculation of each alternative:

a) Addition of Overtime Working Hours

a. Overtime Cost per Day (3 hours)

= (First overtime working hours x 1.5 x normal hourly wage) + (Subsequent overtime working hour x 2 x normal hourly wage) [9]

b. Crash Cost of Labor per Day

= normal cost of labor per day + overtime cost per day

c. Crash Cost

= crash cost of labor per day x crash duration

b) Addition of Labor

The addition of this labor is carried out by adding 50% of the normal labor with consideration of the area of the project location being worked on. The following is the cost formula after the addition of labor:

Crash Cost

= normal cost + (total additional wages x crash duration).

= normal cost + (total additional wages x crash duration).

METHODOLOGY

A. Research Location and Object

The following is a general description of the Outer East Ring Road (OERR) Surabaya Project, which will be the object of this final project research:

- a. Project Name : New Type 2 Collector Road of Lingkar Luar Timur Street (Nambangan - Kyai Tambak Deres Frontage Section).
- b. Location : H. Moh. Noer Street, Tambak Wedi, Kenjeran Subdistrict, SBY City, East Java, 60126.
- c. Project Owner :Surabaya City Government.
- d. Principal Consultant :PT. MCE.
- e. Main Contractor :Prasasti – Tiara – Ayunda, KSO.
- f. Implementation Time :December 2018 – December 2019.
- g. Ready Mix Subcontractor :PT. Merak Jaya Beton.
- h. Precast Subcontractor :PT. Wika Beton.
- i. Building Function :Collector Road.
- j. Contractor Contract Type :Unit Price.
- k. Contract Value :IDR 101.425.709.644,00.
- l. Funding Source : Regional Revenues and Expenditures Budget (APBD).
- m. Budget Year :2018 and 2019.

B. Preparation Stage

The data required in this planning were primary and secondary data obtained from the project. The following data is needed to work on this final project:

a. Primary Data

Primary data was data obtained from the original or first source. This primary data was in the form of interviews with parties involved in project implementation, such as the causes of delays in the project.

b. Secondary Data

Secondary data was data that is already available, so it only needs to be sought, collected, and processed, which is obtained from related agencies. This secondary data was in the form of the following:

1. S-Curve

S-Curve or Schedule was required to determine the time required to complete the project and the schedule or duration of each work activity in the field. S-Curve was also used as a reference for the normal duration of the project.

2. Project Cost Budget

The detailed cost budget was used as a reference for the normal cost. This final project used normal cost data from the Bill of Quantity (BOQ).

3. Supporting Data

Supporting data was used to complement analyzing this final project, such as project drawings and daily reports.

C. Network Diagram Preparation

Literature reviews and studies were carried out by reading the Network Diagram Construction on work activities to find what work activities included in the critical path with the Microsoft Project software assistance program.

D. Trip Assignment Analysis

Before calculating Crash Duration and Crash Cost, the first to do was conducted a crashing plan, or called crashing scenario. Crashing or acceleration was only done on activities that were on the critical path. The crashing scenario was to determine the acceleration alternatives for each activity. In this final project, the crashing scenario used was the addition of working hours (overtime) of 3 hours and the addition of the number of labors.

E. Determine Crash Duration, Crash Cost, and Cost Slope

The crash duration and crash cost were calculated by first finding each work's accelerated productivity. The calculation of accelerated productivity was based on the volume and duration of each work.

a. Crash Duration (CD)

After obtaining accelerated productivity, find the crash duration (acceleration) with the calculation in the equation formula.

b. Crash Cost (CC)

After obtaining the crash duration, the next stage was calculating the crash cost (acceleration cost), calculated by the equation formula.

c. Cost Slope (CS)

After obtaining the crash duration and crash cost, the next stage was to calculate the cost slope of each work using the equation formula.

F. Time Cost Trade Off (TCTO) Analysis

After obtaining the lowest cost slope from the critical path, the next stage was to compress the work activities to get the most optimal cost and time. Compression was only done on critical paths because it could reduce the overall total duration.

G. Total Acceleration Duration Calculation

After calculating the Time Cost Trade Off (TCTO) analysis, the next stage was to recap and calculate the optimum acceleration duration and optimum total cost, where the total cost was obtained from the sum of direct and indirect costs. After getting the optimum result, it was continued by graphing the relationship between time and cost after acceleration.

H. Time and Cost Comparison

After the acceleration, the optimum duration was obtained along with the total cost required. The last thing to do was to compare the results of the two alternatives that have been obtained to get the alternative with the most efficient results.

RESULTS AND DISCUSSIONS

A. Data Processing

After obtaining data from the project to be reviewed, then process the data to obtain the data required to be used in analyzing this study. The following are the data processing results:

Normal Productivity

After obtaining Normal Duration (ND) data, the next step was to get normal productivity and find the crashing

productivity of each work according to the crash scenario that has been formed.

Normal daily productivity was obtained from the division between the volume and duration of each work according to the formula. Here is an example of the calculation:

$$\text{Normal Productivity} = \frac{\text{Work Volume}}{\text{Work Duration}}$$

1. Alternative of additional working hours (overtime)

Example of calculations on Limestone Backfill works with heavy equipment compaction:

- a. Volume = 7294,95 m³
- b. Normal Duration = 54 Days
- c. Normal Productivity = $\frac{7294,95}{54}$
= 135,09 m³/day

Example of calculations on earth excavation works with heavy equipment:

- a. Volume = 1195,05 m³
- b. Normal Duration = 66 Days
- c. Normal Productivity = $\frac{1195,05}{66}$
= 18.10 m³/days

2. Alternative of additional labor

Example of calculations on Limestone Backfill works with heavy equipment compaction:

- a. Volume = 7294,95 m³
- b. Normal Duration = 54 Days
- c. Normal Productivity = $\frac{7294,95}{54}$
= 135,02m³/day

Example of calculations on earth excavation works with heavy equipment:

- a. Volume = 1195,05 m³
- b. Normal Duration = 66 Days
- c. Normal Productivity = $\frac{1195,05}{66}$
= 18.10m³/day

B. Network Diagram Preparation

Preparing the network diagram required the relationship between activities and the duration of each work activity in accordance with the project schedule, or called normal duration. Relationship between activities of each work

After obtaining the relationship between the activities of each work, predecessors, and each work duration, the results of the work on critical paths were obtained. Work on critical paths

C. Crashing Scenario

After calculating the crash duration and cost, the first thing to do was carried out a crash plan or known as a crashing scenario. The acceleration methods to be used are as follows:

1. Additional working hours (overtime)

In planning the additional overtime working hours using 8 normal working hours and 1 hour of rest (08.00-17.00), while overtime work was carried out after normal working hours (17.00-18.00)

2. Additional labor

In addition to the additional overtime working hours, additional labor will be used, where the additional was

taken 50% of normal labor considering the project field conditions.

1). Crashing Productivity

To calculate crashing productivity according to the acceleration alternative that will be used. The following is an example of calculating the crashing productivity of the acceleration alternative to be used.

a) Alternative of additional working hours (overtime)

Example of calculations on Limestone Backfill works with heavy equipment compaction:

- a. Productivity per hour = $\frac{\text{Normal Daily Productivity}}{\text{Normal Working Hours}}$
= $\frac{135.092 \text{ m}^3/\text{day}}{8 \text{ hours}}$
= 16,886 m³/hour
- b. Daily productivity after crash (1 hour) = (normal working hours x productivity per hour) + (overtime working hours x productivity reduction coefficient x productivity per hour)
= (8 hours x 16,886 m³/hour) + (3 hours x 0,6 x 16.886 m³/hour)
= 175.619 m³/jam

Example of calculations on Earth Excavation works with Heavy Equipment:

- a. Productivity per hour = $\frac{\text{Normal Daily Productivity}}{\text{Normal Working Hours}}$
= $\frac{18.107 \text{ m}^3/\text{day}}{8 \text{ hours}}$
= 2.263 m³/hours
- b. Daily productivity after crash (3 hours) = (normal working hour x productivity per hour) + (overtime working hours x productivity reduction coefficient x productivity per hour)
= (8 hours x 2.263 m³/hour) + (1 hour x 0.9 x 2.263 m³/hour)
= 23.539 m³/hour

b) Alternative of additional labor

Example of calculations on Limestone Backfill works with heavy equipment compaction:

$$= \frac{(\text{Normal Productivity} \times \text{number of accelerated labor})}{\text{Number of normal labor}}$$

$$= \frac{135.092 \times 11}{7} = 202,64 \text{ m}^3/\text{day}$$

Example of calculations on earth excavation works with heavy equipment:

$$= \frac{18.107 \times 15}{10} = 27.16 \text{ m}^3/\text{day}$$

D. Acceleration Duration (Crash Duration)

To calculate crashing productivity according to the acceleration alternative that will be used. The following is an example of calculating the crashing productivity of the acceleration alternative to be used:

1. Alternative of additional working hours (overtime)

Example of calculations on Limestone Backfill works with heavy equipment compaction:

$$\text{Volume} = 7294,95 \text{ m}^3$$

$$\text{Daily productivity after crash} = 175.619 \text{ m}^3/\text{hour}$$

$$\text{Crash Duration (CD)} = \frac{\text{volume}}{\text{prod.crashing}}$$

$$= \frac{7294,95 \text{ m}^3}{175.619 \text{ m}^3/\text{hour}}$$

$$= 41.54 \text{ days}$$

2. Alternative of additional labor

Example of calculations on Limestone Backfill works with heavy equipment compaction:

$$\begin{aligned} \text{Volume} &= 7294,95 \text{ m}^3 \\ \text{Accelerated productivity} &= 202,64 \text{ m}^3/\text{hour} \\ \text{Crash Duration} &= \frac{7294,95}{202,64} = 36 \text{ days} \end{aligned}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

$$\begin{aligned} \text{Volume} &= 1195,05 \text{ m}^3 \\ \text{Accelerated productivity} &= 27,16 \text{ m}^3/\text{hour} \\ \text{Crash Duration} &= \frac{1195,05}{27,16} = 44 \text{ days} \end{aligned}$$

E. Normal Cost (NC)

Normal cost is the cost required to complete the work within a normal period. Before calculating the normal cost, it was necessary to calculate the normal cost of labor per hour and the normal cost of labor per day. The following are the stages to calculate the normal cost.

a. Normal cost of labor per day

$$= \text{Unit labor cost} \times \text{Productivity per hour}$$

Example of calculations on Limestone Backfill works with heavy equipment compaction:

$$\begin{aligned} \text{Normal Cost of labor per hour} &= \text{Unit labor cost} \times \text{Productivity per hour} \\ &= \text{IDR } 179.400 \times 16,886 \\ &= \text{IDR } 3.029.431 \end{aligned}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

$$\begin{aligned} \text{Normal Cost of labor per hour} &= \text{Unit labor cost} \times \text{Productivity per hour} \\ &= \text{IDR } 37.410 \times 2,263 \\ &= \text{IDR } 84.672 \end{aligned}$$

b. Normal Cost of labor per day

$$= \text{Normal working hours} \times \text{Normal cost per hour}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

$$\begin{aligned} \text{Normal Cost of labor per day} &= \text{Normal working hours} \times \text{Normal cost per hour} \\ &= 8 \text{ hours} \times \text{IDR } 3.029.431 \\ &= \text{IDR } 24.235.445 \end{aligned}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

$$\begin{aligned} \text{Normal Cost of labor per day} &= \text{Normal working hours} \times \text{Normal cost per hour} \\ &= 8 \text{ jam} \times \text{IDR } 84.672 \\ &= \text{IDR } 677.376 \end{aligned}$$

c. Normal Cost

$$= \text{Normal duration} \times \text{Normal cost of labor per day}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

$$\begin{aligned} \text{Normal Cost} &= \text{Normal duration} \times \text{Normal cost of labor per day} \\ &= 54 \text{ hours} \times \text{IDR } 24.235.445 \\ &= \text{IDR } 1.308.714.030 \end{aligned}$$

Example of calculations on Earth Excavation works with heavy equipment:

$$\begin{aligned} \text{Normal Cost} &= \text{Normal duration} \times \text{Normal cost of labor per day} \\ &= 66 \text{ hours} \times \text{IDR } 677.376 \\ &= \text{IDR } 44.706.821 \end{aligned}$$

F. Crash Cost (CC)

Crash Cost or acceleration cost is the number of labor costs/wages required to complete work with an

accelerated period (crash duration). The stages of crash cost calculation can be seen as follows:

1. Alternative of additional working hours (overtime)

a. Overtime cost per day (4 Hours)

$$= (\text{First overtime working hours} \times 1,5 \times \text{normal hourly wage}) + (\text{Subsequent overtime working hour} \times 2 \times \text{normal hourly wage})$$

Example of calculations on Earth Excavation works with heavy equipment:

Overtime cost per hour (4 Hours)

$$= (\text{First overtime working hours} \times 1,5 \times \text{normal hourly wage}) + (\text{Subsequent overtime working hour} \times 2 \times \text{normal hourly wage})$$

$$= (1 \text{ hour} \times 1,5 \times \text{IDR } 3.029.431) + (2 \text{ hours} \times 2 \times \text{IDR } 3.029.431)$$

$$= \text{IDR } 28.779591$$

Example of calculations on Earth Excavation works with heavy equipment:

Overtime cost per hour (4 Hours)

$$= (\text{First overtime working hours} \times 1,5 \text{ normal hourly wage}) + (\text{Subsequent overtime working hour} \times 2 \times \text{normal hourly wage})$$

$$= (1 \text{ hour} \times 1,5 \times \text{IDR } 84.672) + (2 \text{ hours} \times 2 \times \text{IDR } 84.672)$$

$$= \text{IDR } 465.696$$

b. Crash cost of labor per day

$$= \text{normal cost of labor per day} + \text{overtime cost per day}$$

Example of calculations on Earth Excavation works with heavy equipment:

Crash Cost of labor per day

$$= \text{normal cost of labor per day} + \text{overtime work per day}$$

$$= \text{IDR } 22.620.000 + \text{IDR } 15.551.250$$

$$= \text{IDR } 38.171250$$

Example of calculations on earth excavation works with heavy equipment:

Crash Cost of labor per day

$$= \text{normal cost of labor per day} + \text{overtime cost per day}$$

$$= \text{IDR } 677.376 \times \text{IDR } 465.696$$

$$= \text{IDR } 1.143.072$$

c. Crash Cost (2 hours)

$$= \text{crash cost of labor per day} \times \text{crash duration}$$

Example of calculations on Limestone Backfill works with heavy equipment compaction:

Crash Cost

$$= \text{crash cost of labor per day} \times \text{crash duration}$$

$$= \text{IDR } 38.171.250 + 10 \text{ hours}$$

$$= \text{IDR } 381.712.500$$

Example of calculations on earth excavation works with heavy equipment:

Crash Cost

$$= \text{crash cost of labor per day} \times \text{crash duration}$$

$$= \text{IDR } 1.143.072 \times 55 \text{ days}$$

$$= \text{IDR } 62.868.966$$

G. Cost Slope (CS)

According to (citation), Cost Slope is a calculation of the addition in cost per unit of time. It can provide identification of the cost effect on accelerating the completion time of a project. The greater the crash cost, the greater the cost slope value. The following is an example of Cost Slope calculation for each activity:

$$\text{Cost Slope} = \frac{\text{crash cost} - \text{normal cost}}{\text{normal duration} - \text{crash duration}}$$

1. Alternative of additional working hours (overtime)
 Example of calculations on Limestone Backfill works with heavy equipment compaction:

Crash Cost	= IDR 2.202.163.031
Normal Cost	= IDR 1.308.714.030
Crash Duration	= 42 days
Normal Duration	= 54 days

$$\text{Cost Slope} = \frac{\text{crash cost} - \text{normal cost}}{\text{normal duration} - \text{crash duration}}$$

$$= \frac{\text{IDR 2.202.163.031} - \text{IDR 1.308.714.030}}{54 - 42}$$

$$= \text{IDR 71.696.525}$$

Example of calculations on Earth Excavation works with Heavy Equipment:

Crash Cost	= IDR 75.227.823
Normal Cost	= IDR 44.706.821
Crash Duration	= 51 days
Normal Duration	= 66 days

H. Time Cost Trade Off (TCTO) Analysis

Acceleration or compression analysis will be carried out based on the Cost Slope value that has been obtained previously, where compression started from the lowest Cost Slope to the largest. The stages taken in the compression are as follows:

1. Sort the lowest cost slope of each activity.
2. Activity compression on the critical path with the lowest to largest cost slope manually used finish-to-start constraints.
3. Reorganization of the project work network (PDM) according to the compression results.
4. Repeating the second stage, the repetition stops when there is an additional critical path.
5. If there are two critical paths, the second stage is conducted simultaneously on all critical paths & sum the cost slope.

Stop compression if there is one critical path where the activities cannot be suppressed anymore (saturated) so that cost control is optimal.

I. Total Cost Calculation

Based on the crashing analysis results conducted with the additional working hours (overtime), the project can be accelerated or reach the saturation point at the 133rd acceleration. With the optimum duration result of 137 working days. The following is the calculation of the total acceleration costs:

Indirect cost calculation:

$$= \text{Overhead cost} + \text{Contingency fee (133 days)}$$

$$= \text{IDR 1.844.158.091,72} + \text{IDR 1.383.118.568,79}$$

$$= \text{IDR 3.227.276.660,51}$$

Thus, the total costs are as follows:

$$= \text{Direct cost} + \text{Indirect cost}$$

$$= \text{IDR 92.208.686.805} + \text{IDR 3.227.276.661}$$

$$= \text{IDR 95.435.963.465}$$

J. Cost Efficiency Calculation

- a. Time efficiency calculation

$$= \frac{\text{Normal Duration} - \text{Acceleration Duration}}{\text{Normal Duration}} \times 100\%$$

$$= \frac{270 - 224}{270} \times 100\%$$

$$= 17.04 \%$$
- b. Cost efficiency calculation

$$= \frac{\text{Total Normal Cost} - \text{Total Acceleration Cost}}{\text{Total Normal Cost}} \times 100\%$$

$$= \frac{\text{IDR 95.454.943.709} - \text{IDR 95.438.444.127}}{\text{IDR 95.454.943.709}} \times 100\%$$

$$= 0.02 \%$$

CONCLUSIONS

A. Conclusions

Based on data analysis and discussion of the results of this study on the Outer East Ring Road (OERR) Surabaya project STA (0+000 – STA 5+875), there were two alternatives additional Overtime Working Hours and the Number of Labor. After calculating the value of Crash Duration, Crash Cost, and Cost Slope, Time Cost Trade Off analysis can be carried out and can be concluded as follows:

1. Acceleration alternative of additional working hours (overtime) obtained an acceleration time of 224 days, with a total cost of IDR 95.435.963.465 from the normal cost of IDR 92.207.904.586. It was found that the acceleration alternative using additional working hours (overtime) generated a time efficiency of 17.04%, while cost efficiency decreased by 0.01%.
2. Acceleration alternative of additional labor obtained an acceleration time of 130 days, with a total cost of IDR 95.438.444.127 from the normal cost of IDR 92.207.904.586. It was found that the acceleration alternative using additional working hours (overtime) generated a time efficiency of 51.85%, while cost efficiency decreased by 0.02%.

B. Suggestions

After this study has been completed along with the conclusions above, there are several suggestions from authors for the further progress on the same topic as follows:

1. If there is a delay, it should be accelerated by speeding up the work on the critical path.
2. Based on conclusions that have been obtained, it can be seen that the alternative of additional working hours (overtime) and the number of labors can be considered to be used in accelerating the implementation of construction projects.
3. Acceleration methods and alternatives can use other methods to get more diverse comparisons and find out which acceleration methods or alternatives are more effective.

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