Time Cost Trade Off Analysis on Project Acceleration with Additional Working Hours (Overtime) (Case Study: Building Rehabilitation Project on Dekranasda Hall Of West Kalimantan)

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Abstract
Acceleration on projects is frequently used when there is a mismatch between the actual and planned schedules. In addition, acceleration is frequently implemented in response to requests from the project owner to complete the project as quickly as possible to meet specific goals so that the building can be used immediately. The owner of the Dekranasda Building and Hall in West Kalimantan requested that the project be finished immediately so that the Dekranasda Building could be used as the location for a national UMKM exhibition event. The initial plan for this project was scheduled for 152 working days. Because there would be an exhibition event, the project was accelerated to 128 working days. The purpose of this research is to accelerate the project for 24 days. The stages of this acceleration analysis start from finding what activities can be softened, then compiling a network diagram to identify activities on the critical path, followed by crashing analysis to get crash duration, crash cost, and cost slope, then Time Cost Trade Off analysis is carried out. This research uses the PDM (Precedence Diagram Method) method applied to Microsoft Project to compile a Network Diagram. The results of the acceleration analysis show that the crashing process is carried out until the 12th crashing to meet the target acceleration duration of 128 working days from the normal duration of 152 working days, and the usual 24-day length is shortened. Twelve tasks have been added, raising the overall project cost from Rp. 6,794,007,874 to Rp. 7,091,725,614 by a total of Rp. 297,717,741.

Keyword: Project Acceleration, Microsoft Project, Time Cost Trade Off, Overtime

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1. Introduction
Cost and time are two factors that significantly influence a project's success when being implemented in the construction industry; excellent project management is required to meet these objectives. When building projects are being carried out, there is frequently a discrepancy between the anticipated and actual timelines. Accelerating can be used to get around these delays. Adding workers, increasing worker shifts, increasing working hours (overtime), modifying or adding equipment, choosing qualified human resources, and adopting efficient building techniques are among the approaches that are frequently employed to address these issues. (Saputro, 2015)

The owner of the West Kalimantan Dekranasda Building and Hall Rehabilitation Project requested that the project be finished right away because a national exhibition event will be held at the West Kalimantan Dekranasda Building on November 26, 2022, and the project is intended to be finished before the event is held, so that acceleration is carried out on this project.
The alternative acceleration that can be done by considering the project conditions is by increasing the working hours of the workers, commonly referred to as overtime. The Time Cost Trade-Off method was chosen because this method is considered suitable to be applied to this project, which aims to accelerate the time and minimize the costs incurred on a project. With this method, the project completion target can be accelerated from 152 working days to 128 working days.

2. Materials and Methods

2.1 Definition of Project and Project Management

A project can be defined as a temporary activity within a certain period, allocating specific resources to produce a product whose quality criteria have been determined. Project management is a method planners use in planning, organizing, leading, and controlling resources to achieve target goals within a specified time frame.

2.2 Project Cost

Project costs are divided into three parts: direct costs, indirect costs, and total costs. Direct costs are incurred directly and are closely related to ongoing project activities. Indirect costs are the costs incurred for each project activity but are not directly related to project activities, and these indirect costs consist of overhead costs, unexpected costs, and profits. Total cost is the sum of direct and indirect costs.

2.3 Project Scheduling

Project scheduling is a tool to determine the time required by a project activity for its completion and the start and completion of activities on the project. Scheduling planning on a project consists of scheduling time, workers, equipment, materials, and finance.

2.4 Precedence Diagram Method (PDM)

The Precedence Diagram Method (PDM) is one of the scheduling methods that is often used because, in this method, overlapping project activities can be arranged, where an activity can be done without waiting for the predecessor activity to be completed.

The PDM Method describes activities and events as nodes in rectangular boxes. Each box identifies an activity, and inside each box are smaller boxes called attributes that give details about the activities and events in question. The duration of the activity, its identity (number and name), and occasionally the status of its execution are some of the attributes frequently mentioned and can help with monitoring. (Soeharto, 1995).

Since, in the Precedent Diagram Method, an activity can be done without waiting for the previous activity to be 100% complete, the relationship between activities in PDM develops into several possibilities in the form of constraints. Constraints show the relationship between activities with a line from the previous node to the next node. Here are the constraints on the PDM Method:

- Finish to Start (FS)
  This constraint means that activity (j) cannot be started until activity (i) as the previous activity is completed.

- Start to Start (SS)
  This constraint simply means that activity (j) cannot be started until activity (i) as the previous activity is completed.

- Finish to Finish (FF)
  In simple terms, this constraint can be interpreted as activity (j) not being completed until activity (i) as the previous activity is completed.

- Start to Finish
  In simple terms, this constraint means that activity (j) cannot be completed before activity (i) as the previous activity starts.

2.5 Critical Path

The critical path is the path that has a series of activities with the most extended total duration and shows the fastest duration of project completion. On this path, there are activities that, if implemented late, will cause delays in the overall project.

2.6 Crashing

Crashing is a process that shortens a job's length, affecting the overall duration and speeding up project completion. This crashing process is focused on tasks that are on the crucial route. The method of "crashing" is used to calculate the maximum and most cost-effective duration reduction of an activity that can still be reduced. (Ervianto, et. al., 2004).

2.7 Relationship Between Project Time and Cost

Project acceleration will reduce the duration of project activities (Laksana, et. al., 2017). Both will change according to the time and general progress of the project; the longer the project runs, the higher the cumulative indirect costs required (Soeharto, 1999). Figure 1 is a graph of the relationship between time and cost.
2.8 Time Cost Trade Off
According to Florensia M.A. (2016), the time-cost trade-off is a scheduling technique used to obtain more profitable projects in terms of time (length), cost, and revenue. The Time Cost Trade-Off aims to compress the project within an acceptable period and minimize the total project cost by selecting specific activities.

2.9 Implementation of Additional Working Hours (Overtime)
The more significant the increase in working hours (overtime) can cause a decrease in productivity. Workers typically work 8 hours daily, from 7 am to 4 pm, with an hour of respite in between; overtime is performed after regular working hours have ended. The additional working hours (overtime) can be increased by 1, 2, 3, or 4 hours, depending on the needed additional time. A low worker productivity to an increase in working hours (overtime) can be observed in Figure 2. A more considerable rise in overtime hours can produce a loss in production.

2.9.1 Crash Duration
Crash Duration is the time required to complete the work after an increase in optimal working hours (overtime). To calculate the crash duration of some project activities, it can use the following equations:

1. Daily Productivity = \( \frac{Volume}{Normal \hspace{1mm} duration} \)
2. Hourly Productivity = \( \frac{Volume}{Daily \hspace{1mm} productivity} \)
3. Daily productivity after a crash = (working hours per day × Hourly productivity) + (a × b × Hourly productivity) 
4. Crash duration = \( \frac{Volume}{Daily \hspace{1mm} productivity \ after \hspace{1mm} a \hspace{1mm} crash} \)

2.9.2 Crash Cost
Crash Cost is the total of the project's direct costs throughout the usual duration and what is paid to employees who worked extra. The crash cost will be more than the original normal cost, resulting in a shorter completion time than usual. Overtime cost expenses are regulated by Government Regulation of the Republic of Indonesia Number 35 of 2021 for Specific Time Work Contracts, Outsourcing, Working Time and Rest Time, and Termination of Employment. The formula for calculating overtime wage costs, which is usually called crash cost, is shown below:

- Overtime pays = (1.5 × normal hourly wage) + (2 × normal hourly wage) + ...
- Overtime cost = workers’ overtime pays × number of workers
- Crash cost = direct cost + (total overtime cost per day × crash duration)

2.10 Microsoft Project
Microsoft Project is a program for project planning and management. Microsoft Project is frequently used in project scheduling because it can be used to manage, schedule, estimate, compare, and evaluate projects, and do various other work in projects.

2.11 Research Location
The object of this research is the Rehabilitation of the West Kalimantan Dekranasda Building and Hall project that is located at Jalan Jendral Ahmad Yani, Parit Tokaya, South Pontianak District, Pontianak City, West Kalimantan.

2.12 Data
Collected data in this study is used as material for research analysis, where the obtained data can be classified into two categories:

- This primary data is in the form of interviews with contractors related to the technical implementation of projects in the field and the realization of work in the field.
Secondary data is already available, so it must only be collected and processed from the Contractor, including daily reports, weekly reports, S curves, RAB, unit price lists of wages, materials, tools, and As-built drawings.

2.13 Analysis Method
In this research process, to help guide the research process in a directed and measurable way, the authors designed the research flowchart shown below.

<table>
<thead>
<tr>
<th>No</th>
<th>Things to Consider for Overtime Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Worker's productivity. If the work is done over time, it will not drastically decrease worker productivity because workers will return to work in the morning.</td>
</tr>
<tr>
<td>2.</td>
<td>Worker's health and safety. This is a significant consideration for choosing activities that will be done over time so that workers are not too tired at work, which will result in accidents at work.</td>
</tr>
<tr>
<td>3.</td>
<td>The activities are included in the critical path, and if the work is done over time, it will affect the project's total duration. Even if it has a small crashing value and a cost slope value that is not too large, the activity will still be done over time.</td>
</tr>
</tbody>
</table>

3.2 Project Normal Duration Analysis
Work stages and average duration are needed to determine the expected duration without acceleration. Due to the scheduling data obtained only in the form of a bar chart, a reschedule is carried out using the PDM Method, so it is necessary to calculate the average duration to determine the duration of each project activity. The following is an example of analysing the standard calculation of project duration for HBM Steel 175 x 175 x 7.5 x 11 mm work referring to the Regulation of the Minister of PUPR Number 1 of 2022 concerning Guidelines for Preparing Construction Work Cost Estimates in the Field of Public Works and Public Housing.

1. Volume of work = 9755.68 kg
2. The amount of human resources available per day
   a. Worker = 10 people
   b. Steelworker = 10 people
   c. Handyman head = 1 people
   d. Foreman = 1 people
3. The amount of human resources Productivity

   \[ \text{Productivity} = \frac{1}{\text{coefficient}} \times \frac{\text{Total availability worker}}{	ext{day}} \]

   a. Worker
   \[ \frac{1\,\text{kg}}{0.0600\,\text{H}} \times 10 \,\text{people} = 166.67 \,\text{kg/H} \]
   b. Steel worker
   \[ \frac{1\,\text{kg}}{0.0600\,\text{H}} \times 10 \,\text{people} = 166.67 \,\text{kg/H} \]
   c. Handyman Head
   \[ \frac{1\,\text{kg}}{0.0060\,\text{H}} \times 1 \,\text{people} = 166.67 \,\text{kg/H} \]
   d. Foreman
   \[ \frac{1\,\text{kg}}{0.0030\,\text{H}} \times 1 \,\text{people} = 333.33 \,\text{kg/H} \]
The longest duration is used to determine the normal duration of a job, so that for HBM Steel work 175 x 175 x 7.5 x 11 mm, it is 59 days.

3.3 Building a Network Diagram
After knowing the standard duration of each job with the help of Microsoft Office Project 2019 software, it is arranged between activities and expected duration to get a network diagram so that forward and backward calculations can be done to get activities on the critical path. Microsoft Office Project 2019 helps speed up the process of making network diagrams because this project has many work items. Once the duration and predecessor relationships for each activity are entered, a complete network of precedence diagrams containing the earliest start time (ES), earliest finish time (EF), latest start time (LS), and latest finish time (LF) of a single activity will be acquired, to identify the critical path, total float, and project completion time.

3.4 Crash Duration Analysis
Crash Duration is the time needed to complete work after an increase in optimal working hours (overtime). Here is one of the crash duration analysis for HBM 175 x 175 x 7.5 x 11 mm Steel Structure:

1. Volume = 9755.68 kg
2. Normal duration = 59 days
3. Normal duration on hour = 59 days x 8 working hour = 472 hour
4. Worker productivity per hour = \( \frac{9755.68 \text{ kg}}{472 \text{ jam}} \) = 20.67 kg/hour
5. Worker productivity after crash = (working hour × worker productivity per hour) + (overtime hour × decreased productivity coefficient × worker productivity per hour) = (8 hour × 20.67 kg/hour) + (3 hour × 0.7 × 20.67 kg/hour) = 208.76 kg/days
6. Crash duration = \( \frac{9755.68 \text{ kg}}{208.76 \text{ kg/days}} \) = 46.744 days ≈ 47 days
7. Crashing
   = Normal duration – Crash duration = 59 days – 47 days = 12 days

Based on the calculation above, it was found that the work of the HBM 175x175x7.5x11mm Steel structure can be accelerated by overtime work and produce a crash duration of 47 days where there is a reduction in days for 12 days from the normal duration of 59 days. For other jobs the same calculation is carried out.

3.5 Crash Cost Analysis
Crash Cost is calculated from the sum of direct costs under normal conditions plus the total cost of workers’ overtime wages. The following is an example of crash cost calculation for HBM 175 x 175 x 7.5 x 11 mm Steel Structure Work:

1. Normal costs / direct cost = Rp. 363,403,958
2. Normal duration = 59 days
3. Crash duration = 47 days
4. Number of workers overtime
   a. Worker = 10 people
   b. Craftsman = 10 people
   c. Handyman head = 1 people
   d. Foreman = 1 people
5. Normal hourly wage of workers = \( \frac{1}{8} \) x wage of worker 1 day
   a. Worker = \( \frac{1}{8} \) x IDR 110,000 = IDR 13,750 / hour
   b. Handyman = \( \frac{1}{8} \) x IDR 130,000 = IDR 16,250 / hour
   c. Handyman's head = \( \frac{1}{8} \) x IDR 150,000 = IDR 18,750 / hour
   d. Foreman = \( \frac{1}{8} \) x IDR 20,000 = IDR 2,500 / hour
6. Overtime pay of workers for 3 hours = (1.5 x normal hourly wage) + (2 x normal hourly wage) + (2 x normal hourly wages)
Based on the above calculations, it is found that the HBM 175 x 175 x 7.5 x 11 mm Steel Structure Work can be accelerated with overtime work and results in a cost slope of Rp.7,297,240/day. For other work, the same calculation is carried out.

3.9 Time Cost Trade Off Analysis

This analysis is done by compressing (emphasizing) activities on the critical path. Starting from the crash process that continues to be carried out until the planned acceleration target is achieved, which is to accelerate the project duration from 152 working days to 128 working days. Because a new critical path will be formed after every crushing process, this process is carried out repeatedly until the acceleration target is achieved. To achieve the acceleration target, the author makes the crashing value the main factor in selecting overtime activities to achieve the project target because, at the limit of this research problem, financial resources are assumed to be available and conducive. Table 3 will explain the process of calculating the compression stage with the alternative of adding optimal working hours (overtime):

Table 3. Result of Time Cost Trade Off Analysis

<table>
<thead>
<tr>
<th>Crashing - Normal Duration</th>
<th>Total Duration</th>
<th>Direct Cost (Rp)</th>
<th>Indirect Cost (Rp)</th>
<th>Total Cost (Rp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>152</td>
<td>144</td>
<td>6,226,048,108</td>
<td>867,685,323</td>
<td>7,094,733,431</td>
</tr>
<tr>
<td>1</td>
<td>140</td>
<td>6,218,468,858</td>
<td>860,717,904</td>
<td>7,079,186,762</td>
</tr>
<tr>
<td>2</td>
<td>139</td>
<td>6,242,605,008</td>
<td>890,597,219</td>
<td>7,033,202,527</td>
</tr>
<tr>
<td>3</td>
<td>138</td>
<td>6,236,260,080</td>
<td>892,350,516</td>
<td>7,085,610,596</td>
</tr>
<tr>
<td>4</td>
<td>135</td>
<td>6,236,260,648</td>
<td>844,927,975</td>
<td>7,081,200,640</td>
</tr>
<tr>
<td>5</td>
<td>134</td>
<td>6,231,371,585</td>
<td>843,510,516</td>
<td>7,074,882,100</td>
</tr>
<tr>
<td>6</td>
<td>133</td>
<td>6,235,964,358</td>
<td>842,030,025</td>
<td>7,078,007,383</td>
</tr>
<tr>
<td>7</td>
<td>132</td>
<td>6,240,732,403</td>
<td>840,576,555</td>
<td>7,087,408,958</td>
</tr>
<tr>
<td>8</td>
<td>131</td>
<td>6,244,411,233</td>
<td>839,258,074</td>
<td>7,083,699,307</td>
</tr>
<tr>
<td>9</td>
<td>130</td>
<td>6,243,987,463</td>
<td>827,840,530</td>
<td>7,081,828,060</td>
</tr>
<tr>
<td>10</td>
<td>129</td>
<td>6,257,984,983</td>
<td>826,423,113</td>
<td>7,094,408,096</td>
</tr>
<tr>
<td>11</td>
<td>128</td>
<td>6,256,719,983</td>
<td>825,026,632</td>
<td>7,091,725,614</td>
</tr>
</tbody>
</table>

(Source: Analysis Result, 2023)

4. Conclusion

After analyzing the data on project duration acceleration by adding working hours (overtime) using the Time Cost Trade-Off method on the West Kalimantan Dekranasda Building Rehabilitation project, the following conclusions were obtained:

1. To achieve the project acceleration target, from 152 working days to 128 working days, additional working hours (overtime) are carried out, with a standard working duration of 8 hours, starting at 07.00 - 16.00 WIB with a 1-hour break plus additional working hours (overtime) for 3 hours beginning at 18.00 -
21.00 WIB. There is a reduction in duration for 24 days.

2. In the process of accelerating the Rehabilitation of West Kalimantan Dekranasda Building and Hall project to achieve the project acceleration target, there was an increase in the total project cost of Rp.297,717,741 from the original total project cost of Rp6.794.007,874 to Rp7.091.725.614.

5. Acknowledgement
Praise from the author goes to the presence of Allah Subhanahu Wa Ta’ala, because of His mercy and grace, that I could have completed this final project. In addition, I also thanks to my beloved parents and beloved younger siblings, as well as my boyfriend and my best friends, who always provide support, love and unceasing prayer. I also thank to Mrs. Lusiana, Mr. Rafie, Mr. Syahrudin, and Mr. Safaruddin, also Mrs. Elsa as the lecturers who have guide, help and given so many suggestions. I hope that this journal could be useful for students and readers as reference, especially with regard to construction project management.

6. Author’s Note
The contents of making this journal are written based on research results with the help of Mrs. Lusiana and Mr. Rafie as the advisor lecturer and has completed his undergraduate thesis for the Civil Engineering Study Program at Tanjungpura University.

7. References


