INTERNATIONAL JOURNAL ON ADVANCED TECHNOLOGY, ENGINEERING, AND INFORMATION SYSTEM (IJATEIS)

TIME AND COST ACCELERATION ANALYSIS USING CRASHING METHOD (CASE STUDY: TANJUNG UNCANG JETTY CONSTRUCTION PROJECT BATAM CITY)

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Abstract

Contractors involved in construction projects face the crucial challenge of effectively managing time to ensure the timely completion of the project as stipulated in the contract, if not earlier. Efficient time management not only facilitates adherence to contractual obligations but also transforms incurred costs into profitable outcomes, thereby preventing financial penalties associated with project delays. Consequently, the strategic implementation of acceleration efforts emerges as a pivotal solution to address and mitigate the complexities inherent in construction project timelines. The acceleration process is intricately tied to the identification and prioritization of critical activities within the project schedule. By employing a comprehensive approach that integrates both cost and time analyses, the Crashing method with additional modifications emerges as a valuable tool in this endeavor. The Crashing method involves a strategic acceleration of critical activities, coupled with a meticulous calculation of the additional costs incurred due to the acceleration process. A compelling case study that exemplifies the efficacy of the Crashing method and its supplementary measure of alternative overtime work is evident in the Tanjung Uncang Pier construction project in Batam City. Through the meticulous application of the Crashing method and the incorporation of alternative overtime work, the project's completion timeline was successfully curtailed from the originally delayed schedule of 257 calendar days to a more expedited 244 calendar days.

Keywords: *Project, Construction, Delay, Crashing Method, Project Acceleration*

1. INTRODUCTION

Time, quality and cost are three important components in planning a construction project. The benchmark for a successful construction project is the completion time according to the time period provided, the minimum cost and without overriding the quality in development.

The contractor must be able to manage a construction project systematically so that the project completion time is in accordance with the contract or even faster so that the costs incurred can be a benefit or profit and can also avoid fines due to delays in completing construction projects therefore acceleration is important to do to overcome delays (Inkiriwang, 2019).

Acceleration is carried out on critical activities and what must be done in analyzing the cost and time of the project is to create a project work network (network), find critical activities and calculate the duration of the project. The method used is the crashing method with alternative overtime work(Simatupang et al., 2015).

This study also uses the help of the Microsoft Project program to find critical activities(Kusrianto, 2013). The crashing method is done by accelerating the duration of critical activities, then calculating the crashing costs that occur due to acceleration.

2. LITERATURE REVIEW

2.1. Project

Projects can be interpreted as activities that take place within a certain period of time aimed at achieving certain goals by using a certain allocation of resources. If not handled properly, activities in the project will result in the emergence of various negative impacts which ultimately lead to failure in achieving the goals and objectives envisioned (Dipohusodo, 1996).

2.2. Project Management

Project management is a technique used to plan, perform, and control the activities of a project to meet project time and cost constraints (Muslich, 2009). Project management is planning and supervision (Jamshid Parvizian, 2004). Project management is also the scheduling and supervision of project activities to achieve performance, cost and time objectives, for a predetermined scope of work using resources efficiently and effectively(Soeharto, 1997).

2.3. Project Acceleration

According to (Ervianto, 2004), the terminology of the crashing process is to reduce the duration of a job that will affect the project completion time. Shortening the duration of course must increase resources, including costs and accelerate the implementation of activities(Wohon et al., 2015). As a result of more activities being shortened, there is an increase in the cost of the work item, but the total cost of the work will be minimized from the total cost that should be incurred due to the delay.

The conditions that occur in the field result in alternative control based on the overtime method. The calculation is done by analyzing the cost slope and price after the crash program. The crashing program according to Husen (2010), is carried out on activities that are on the critical path. To speed up the work completion process there are several ways, namely:

a. Addition Of Working Hours (Overtime)

Overtime work can be done by increasing working hours every day, without increasing the number of workers. This overtime work contains danger and the work will be very heavy. Therefore, overtime work must receive additional wages that are greater than normal work wages, usually 1.5 to 2 times the normal work wage. In addition, it is necessary to provide other additional equipment such as lights, work safety, health facilities and increased quality control due to decreased work ability of the workforce.

b. Division of shifts

Making shifts is almost the same as increasing working hours. But here there is an increase in the number of workers, because the morning to afternoon shift worker unit is different from the afternoon to evening shift worker unit. Assuming that productivity remains the same, then:

a. Work shifts are rotated regularly.
b. An effort is made to make a worker equal to his shift team so that his productivity is high.

c. Addition of labor

The addition of labor is intended as an increase in the number of workers in a unit of workers to carry out an activity without increasing working hours. The optimum addition of labor will increase work productivity, but too much addition will actually reduce work productivity because there is too little land to work or other things, for this reason it is necessary to pay attention to the following things:

a. The capacity of the place to accommodate the number of workers.
b. Ease / freedom in carrying out work.
c. Supervision of labor.
d. Work safety.

d. Addition/replacement of equipment

The addition/replacement of equipment is intended to increase work productivity, get more work accuracy and reduce the amount of human labor. The addition of tools needs to consider the following factors:

a. Addition of operators and equipment mechanics.
b. Place capacity.
c. Cost and time required for equipment mobilization and demobilization.

Replacement of equipment with productivity greater than the money spent can also be achieved to achieve a crash program.

e. Change or improvement of work methods

Changing or improving work methods is done when the existing methods are too slow and inefficient. For example, manually mixing a concrete mixture will take longer than using a concrete molen. However, changing the work method sometimes also changes the logical relationship of the activity network or even the type of activity itself.

f. Concentration on certain activities

Accelerating project completion can be done by concentrating specifically on activities on the critical path(Pratasik et al., 2013). This concentration is defined as the addition / transfer of labor and / or equipment in that activity. Things that need to be considered are:

a. Transferring labor to new activities will reduce work productivity at first because there is a learning phase.

b. The delay of non-critical activities does not exceed the float it has.
c. The addition of labor and or equipment to critical activities must pay attention to the optimum amount.

g. Combination of existing alternatives.

In its implementation, this duration acceleration can be done by combining existing alternatives so as to produce a method that suits the project. Especially on large projects that have many activities.

2.4. Additional Labor Cost (Crash Cost)

With the addition of working time, the cost for labor will increase from the normal cost of labor. Based on the Decree of the Minister of Manpower and Transmigration of the Republic of Indonesia Number KEP. 102 / MEN / VI / 2004 that wages for additional work vary, for the first additional hour of working time, workers get an additional wage of 1.5 times the normal hourly wage, and for the addition of the next working time workers get 2 times the normal hourly wage. The calculation of additional worker costs can be formulated as follows:

1. Normal worker cost per day = daily productivity x unit price of worker wages
2. Normal worker cost per hour = productivity per hour x unit price of worker wages
3. Worker overtime cost = (1.5 x normal hourly wage for the first overtime work hour) + (2 x n x normal hourly wage for the next overtime work hour)
4. Crash cost per day = (7 hours x normal worker cost) + (n x overtime cost per hour)
5. Cost Slope (the addition of direct costs to accelerate an activity per unit time)

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

3. RESEARCH METHODS

Methodology is the process, principles, and procedures we use to approach problems and seek answers. In other words, methodology is a general approach to studying a research topic. Methodology is influenced or based on the theoretical perspective we use to conduct research, while the theoretical perspective itself is an explanatory or interpretative framework that allows researchers to understand data and connect complex data with other events and situations.

The method used in this research is descriptive quantitative, research that describes the condition of a particular project by analyzing existing data. Data analysis uses analytical and descriptive methods. Analytical means that existing data is processed in such a way as to produce final results that can be concluded. While descriptive means that by describing the problems that already exist or appear. the research was conducted on the Tanjung Uncang Pier Construction project in Batam City. Measurement of time cost and project cost performance is carried out by the Earned Value method. The advantage of this method is that it can describe the relationship between the work that has been completed with the budget that has been allocated for the work. From the results of the

analysis can be known activity performance which can later be known to calculate the cost of completing the rest of the work.

4. RESULTS AND DISCUSSION

4.1. Project Data

The research location is the Tanjung Uncang Pier Construction Project in Batam City in 2023.

Owner : PT PAX OCEAN
Executor : PT. TRI SYNERGY PERSADA
Total value of HPS : Rp. 40,236,396,033.00 (NK-PPN)
Implementation : 245 Calendar Days

The implementation of the Tanjung Uncang Pier Construction Project at Batam City is 245 calendar days. The review was conducted on week 22 with the following schedule of work implementation plan:

Table 1. schedule of the implementation plan for the construction of the Tanjung Uncang pier in batam city.

NO	JOB DESCRIPTION	-VAT VALUE	WEIGHT -PN
1	Preparation and General Items:	503.756.238,00	1,25
2	Piling Work	4.006.870.104,00	9,96
3	Sheet Pile Works	16.773.569.000,00	41,69
4	Concrete G35 Pile cap 1500x1500x800 c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	2.549.673.607,00	6,34
5	Concrete G35 Anchore 400x1200mm c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	1.601348.069,00	3,98
6	Concrete G35 Cover head 1000x2000mm c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	1.778.147.441,00	4,42
7	Concrete G35 Beam dilatasi 1000x800mm c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	176.182.604,00	0,44
8	Concrete G35 Beam 500x800mm c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	1.123.082.667,00	2,79
9	Concrete G35 Beam to existing berth 300x500mm c/w rebar, form, excavation, compaction base, sand fill, lean concrete and backfill	412.009.487,00	1,02
10	Concrete G35 cover deck 300mm thick c/w rebar, form, levelling, compaction base,	6.840.506.064,00	17,00
11	Concrete G35 Rail Beam 500x800mm c/w rebar, form, levelling, compaction base,	1.823.556.162,00	4,53
12	Steel Tie rod 50mm c/w support, cover plate, steel plate, steel channel	722.201.119,00	1,79
13	Bollard Capacity 40 Ton, along side the wharf	1.187.040.589,00	2,95
14	Rubber Fender, supply and install.	319.785.863,00	0,79

NO	JOB DESCRIPTION	-VAT VALUE	WEIGHT -PN
15	Dredging Works to clean construction debris along the berth 9	109.400.427,00	0,27
16	Backfill to raise the elevation of deck.	309.266.592,00	0,77
	TOTAL	40.236.396.033,00	100,00

Source: Project Data

4.2. Acceleration of Project Implementation

After analyzing the implementation of the Tanjung Uncang Pier construction work in Batam City using the Earn Value Analysis method, it was found that the project was delayed in its implementation, so an acceleration option was carried out to see how fast the implementation time and how much the costs incurred after the acceleration was carried out in the work time(Priyo & Sumanto, 2016). The work items that will be accelerated are those that are on the critical trajectory, to see what work is included in the critical trajectory, the Microsoft Project application is used.

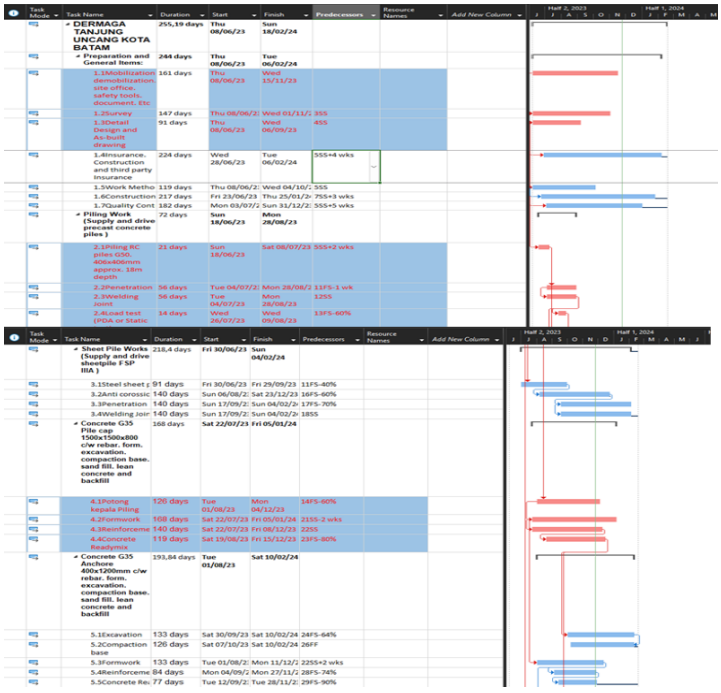

Figure 1. Work items that are on the critical trajectory,
Source: Author's Process Results, 2023

4.3. Analysis Using Crash Program

Crash program is one way to accelerate the project completion time, namely by reducing the completion time of activities that are on the critical trajectory that will affect the project completion time. The work that is on the critical trajectory is the Piling Work and Concrete G35 work, but because the review is carried out in week 22 where the Piling Work has been completed, the acceleration will be carried out on the Concrete G35 work. Acceleration of the completion of the Tanjung Uncang Pier Construction Project in Batam City is done by using overtime hours. The work plan that will be carried out in

accelerating the completion time of an activity with the overtime hour method is as follows:

a. Normal activities use 8 hours of work and 1 hour of rest (08.00-17.00 WIB), while overtime work is carried out after normal working time for 4 hours per day (18.00-22.00 WIB). Overtime labor is the same as regular labor.
b. The wage rate of workers for overtime work is calculated at 2 times the hourly wage at normal working time.
c. Productivity for overtime work is calculated at 60% of normal productivity. The decrease in productivity is due to fatigue, limited visibility at night and colder weather conditions.

4.4. Calculating the Acceleration of Work Completion Time

The calculation of the acceleration of project completion time is carried out on the work on the critical trajectory, namely the Concrete G35 work.

a. Cut Head Piling Work:

Daily productivity = (work weight)/(planned duration)
Daily productivity = 0.13/126 = 0.001013
Hourly productivity = (Daily productivity)/(8 hours)
Hourly productivity = 0.001013/(8 hours) = 0.00013
Furthermore, the activity completion time after the crash:
Daily productivity after crash = (8 x 0.00013) + (4 x 0.6 x 0.00013) = 0.0013
Completion time = 0.13/0.0013 = 96.92 days

So the time needed to complete the piling head cutting work after the crash is 96.92 days, so the accelerated time is 29.08 days.

Table 2. Time acceleration on critical path

TANJUNG UNCANG JETTY BATAM CITY	Duration Plan	Turnaround Time	Accelerated Time
Concrete G35 Pile cap 1500x1500x800 c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
4.1Potong kepala Piling	126	96,923077	29,076923
4.2Formwork	168	129,23077	38,769231
4.3Reinforcement	140	107,69231	32,307692
4.4Concrete Readymix	119	91,538462	27,461538
Concrete G35 Anchore 400x1200mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
5.3Formwork	133	102,30769	30,692308
Concrete G35 Cover head 1000x2000mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
6.1Formwork	147	113,07692	33,923077

TANJUNG UNCANG JETTY BATAM CITY	Duration Plan	Turnaround Time	Accelerated Time
Concrete G35 Beam dilatasi 1000x800mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
7.1Formwork	126	96,92	29,076
Concrete G35 Beam 500x800mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
8.1Formwork	140	107,69	32,307

Source: Author's Results, 2023.

4.5. Calculating the Crash Cost of Work

As a result of accelerating the time for completion of activities, there is an increase in costs in terms of payment of workers' wages or known as the crash cost of workers. Broadly speaking, the calculation is carried out as follows:

a. Cut Head Piling Work:

Calculating the normal daily labor rate $= \frac{total\ price\ of\ labor}{normal\ activity\ completion\ time}$

$= \frac{51.334.046}{126}$ = Rp. 407.413

Calculating the normal hourly labor rate $= \frac{normal\ daily\ labor\ wage}{8}$

$= \frac{Rp.407.413}{8}$ = Rp. 50.927

Calculating overtime pay for 1 day = 4 (2 x normal hourly wage)
= 4 (2 x Rp. 50,927) = Rp. 407,416

Calculating the crash cost wage of workers per day = (8 x Rp. 50,927) + Rp. 407,416
= Rp. 814,832

Calculating the total crash cost duration = crash cost of workers per day x crash
= Rp. 814,832 x 96.9 days
= IDR 78,957,220

After calculating the crash cost, then calculate the cost slope of each job.

Table 3. crash cosh total dan cost slope

Job Name	Valuework	Crashcosttotal	Costslope
Concrete G35 Pile cap 1500x1500x800 c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
4.1Potong kepala Piling	51.334.046,34	78.956.652,22	27.622.605,89
4.2Formwork	249.312.351,71	383.555.181,08	134.242.829,38
4.3Reinforcement	1.684.352.699,69	2.591.496.939,38	907.144.239,69
4.4Concrete Readymix	564.674.509,70	868.649.712,15	303.975.202,45
Concrete G35 Anchore 400x1200mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
5.3Formwork	93.846.491,09	144.382.473,74	50.535.982,65
Concrete G35 Cover head 1000x2000mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
6.1Formwork	194.933.794,35	299.959.348,86	105.025.554,51
Concrete G35 Beam dilatasi 1000x800mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
7.1Formwork	21.855.774,12	33.624.267,87	11.768.493,76
Concrete G35 Beam 500x800mm c/w rebar. form. excavation. compaction base. sand fill. lean concrete and backfill			
8.1Formwork	149.222.181,91	229.572.587,55	80.350.405,64

Source: Author's Results, 2023.

4.6. Calculating Total Cost After Acceleration

After the crash cost calculation is obtained, the work completion time is 244 days, then the total cost of work and additional costs of each crash work can be summed up.

So the total cost due to crash:

= Direct cost + indirect cost

= Rp. 37,690,283,913 + Rp. 4,187,809,324 = Rp. 41,878,093,237

5. CONCLUSION

In accordance with the research objectives and the results of the discussion, it can be concluded that the time required to complete the construction of Tanjung Uncang Pier Batam City is 244 days with a total cost of Rp. 41,878,093,237.

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