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

ANALYSIS OF TIME AND COST ACCELERATION USING CRASHING METHOD WITH ADDITIONAL WORKING HOURS ON THE CONSTRUCTION PROJECT OF COTTON BRIDGE - GLENDENG 8 BOJONEGORO DISTRICT

Subkhan Ariyanto[1*], Hanie Teki Tjendani[2], Budi Witjaksana[3]
[1-3] Master of Civil Engineering Study Program, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya
E-mail: [1)] subkanhariyanto5@gmail.com

Abstract
Infrastructure development plays a very important role as capital in efforts to stimulate increased economic productivity, both at the national and regional levels, as well as reducing unemployment, alleviating people from poverty and of course improving the standard of living of the community at large. Delays in completing a project are a problem that often arises and can have an impact on the entire work, especially with time delays resulting in increased costs which can be detrimental to many parties. This delay also occurred in the Kapas-Glendeng 8 bridge construction project, Bojonegoro Regency. In anticipation of these delays, it is necessary to accelerate time and costs. In this research the author uses the crashing method with the alternative of increasing working hours. The crashing method is a way of estimating cost variables to determine the maximum and most economical reduction in the duration of an activity that is still possible to reduce. The research results showed that the total time and cost of the project required after crashing was 174 calendar days with a cost under accelerated conditions of Rp. 2,555,189,555.98 with a difference of 6 calendar days from the normal duration of 180 calendar days and a fee under normal conditions of Rp. 2,548,581,990.63.

Keywords: *Time and Cost Analysis, Crashing Method, Additional Working Hours*

1. INTRODUCTION

Massive and equitable infrastructure development in all corners of the country over the past 5 (Five) years has become the foundation for Indonesia's future progress (UMUM 2016). Infrastructure development is very important especially for Indonesia, an archipelago with unique geographical conditions in it so that efforts to improve connectivity between regions and efforts to make equity by prioritizing development in regions and villages continue to be improved (Muhyi 2018). Infrastructure development plays a very important role as capital in an effort to spur increased economic productivity, both at the national and regional levels, as well as reduce unemployment, alleviate people from poverty and of course improve the standard of living of the community at large (Yaqin 2023). Therefore, the government is committed to continuously improving infrastructure development, because the availability of reliable infrastructure is very important to support economic growth and growth in the business world.

On the island of Java, one of the districts that continues to equalize infrastructure development is Bojonegoro Regency. Bridge construction and rehabilitation are part of the infrastructure development in Bojonegoro Regency. The construction of the Kapas - Glendeng Bridge in Kapas District is a bridge that can be used to support the smooth

activities of the people of Bojonegoro Regency, especially the Kapas Village community and its surroundings so as to improve the economy, health, and human resources. Kapas - Glendeng Bridge with a composite bridge type design with a span of 24.68 meters and a height of about 7.4 meters from the river level with pillars and abutments on the south side towards Kapas District and abutments on the north side towards Tuban Regency.

The implementation of this bridge work uses funds from the 2023 Bojonegoro Regency APBD with a contract value of Rp. 2,828,926,009.60 which is carried out by CV Merdeka with an implementation time in the contract of 180 calendar days. The period of work implementation or the period for carrying out work is calculated based on the Work Implementation Order (SPMK) until the first handover of work. The implementing contractor is obliged to complete the work within the period of work implementation as stated in the LDP, based on the general conditions and special conditions of the contract with quality according to the technical specifications and prices stated in the contract.

The implementation of a construction project is a collection of work systems that influence each other. In general, a construction project that is carried out will always have a high risk, so from that high risk it is the basis for why a planning and implementation in the completion of project work is carried out precisely and carefully. As for the problems that are often faced in project implementation, starting from planning implementation time, labor, costs, equipment and so on. Resources are planned to achieve project targets with time, cost and quality constraints (Rosyid et al. 2020). In addition to quality, time and cost are very important in the implementation of construction work, because the costs that will be incurred during implementation are closely related to the time of work. The measure of the success of a project is seen from the short completion time at a minimum cost without overriding the quality of the work. The implementation of work on a project requires not only reliable human resources, but also good management. Good management is needed as an effort in handling projects systematically which is needed to ensure project implementation time according to the contract and can avoid fines due to delays in project work. With good project control, the acceleration of completion time is expected to run effectively without causing losses. The Kapas-Glendeng 8 Bridge of Bojonegoro Regency has an important meaning for the smooth transportation of goods and passengers, so the Kapas-Glendeng 8 Bridge project of Bojonegoro Regency is expected to be completed within the planned time, so that it can immediately operate and be used as needed. There are several things that cause delays, namely resource readiness/preparation, work planning and scheduling, organizational system, coordination and communication, scope and work documents, inspection system, work control and evaluation, and others.

In reality, in a project cannot be separated from the obstacles that hinder which result in delays in completion. Delays in completing a project are a problem that often arises and can have an impact on all work in a project, especially with time delays resulting in increased costs so that it can harm many parties (Budianto and Husin 2021). The progress reported by the supervisory consultant is always in a minus deviation state, meaning that the progress of realization in the field is still below the planning progress. In the first week according to the time schedule contained in the S curve, the progress deviated -0.75 from the planned progress. In the second week the progress experienced a

deviation of -1.59, in the third week the progress was still experiencing delays with a deviation of -2.11. Furthermore, in the fourth week from the planned progress of 2.62, progress of 0.14 was still realized, resulting in a deviation of -2.49. In the following week, the fifth week of progress in the field also experienced delays so that progress was still at -3.03. Followed by the progress report in the sixth week, in fact in the sixth week of the second month the implementation delay also still occurred, in the sixth week the delay was -3.81 from the planned progress of 3.95. The seventh week of the planned progress of 4.63 was only realized by 0.56, resulting in a delay of -4.07. Broadly speaking, the delay that occurred in the Kapas-Glendeng 8 bridge construction project in Bojonegoro Regency was due to the pile items in the procurement and delivery process experiencing delays, so that the delay also affected the delay in the implementation of other items. From the information obtained, the delay in progress that occurred in the Bridge Construction project - Kapas Glendeng 8 Bojonegoro Regency was caused by several things, ranging from delays in the start of work, weather, to delays in pile material.

Acceleration of project duration can be done by utilizing existing alternatives such as increasing working hours, increasing labor, using a shift work system, using more effective construction methods and using fast materials. This can indeed shorten the project implementation time, but on the other hand the cost of project implementation will increase. The project acceleration analysis must be carefully calculated so that the project duration remains as scheduled and the costs incurred do not swell. In the initial planning of a project, the factors of cost, time and quality form an interdependent relationship and have a very strong influence, therefore the acceleration of project completion must also be done with good acceleration. By utilizing optimal time, the alternative used to support the acceleration of activities is to increase working hours or provide additional working hours (overtime) / work shifts. Through the acceleration of the project, both the owner and the contractor both benefit. The owner benefits because the Kapas - Glendeng 8 Bridge construction project in Bojonegoro Regency can function faster. Likewise, the contractor can reduce indirect costs that may arise due to the duration of work that is too long, as well as a step to overcome project delays.

From the progress report data above, in anticipation of the delay, it is necessary to accelerate the time and cost with several control tools so that it can be prevented by optimizing acceleration in its implementation while still considering the cost factor and maintaining quality or quality standards. Some methods that can be used to accelerate the scheduling of a project include the crashing method, TCTO (Time Cost Trade off) method, fast track method and least cost analysis method. In this research, the author uses one method, namely the crashing method with the alternative of adding working hours (overtime)(Irawan and Juara 2022). The application of other alternatives such as increasing the number of workers cannot be applied to the project because of the difficulty of finding additional labor due to other activities that cannot be abandoned, one of which is taking care of agriculture.

The crashing method is also one of the programs which is commonly used to shorten the duration of a project's activities, where activities that can be crashed are activities that are on the critical path Wardana and Putra (2023); Wijanarko and Oetomo (2019); Zuhriyah and Oetomo (2022). The application of the crashing method to the project is to

determine the optimum duration obtained with the alternative of adding working hours (overtime) in order to minimize the duration of the project.

2. RESEARCH METHODS

Data collection is carried out by collecting data related to this research, the data obtained is secondary project data, namely the Cost Budget Design (RAB), Time Schedule, and project work plan schedule or S Curve.

Research subjects or respondents are parties that can be used as samples in a study. And also discusses the characteristics of the subjects used in the study including an explanation of the population, sample and sampling techniques used. The subject in this study is the addition of working hours. In this case, the object of research will be focused on the cost and time of the work of acceleration results analyzed as dependent variables. The location where this research was conducted was the Kapas - Glendeng 8 Bojonegoro bridge construction project located in Kalirejo Village, Kapas District, Bojonegoro Regency, East Java.

The instruments or tools used in conducting cost and time analysis research on the Kapas Glendeng 8 Bridge Construction Project of Bojonegoro Regency using the crashing method are laptops and computers. The laptop is used to compile the thesis starting from inputting research data data, then processing the data obtained using the Microsoft excel application, Microsoft Project which is poured on Microsoft word, and to present the research results using Microsoft power point.

Data collection procedures in the research of Cost and Time Analysis of the Kapas Glendeng 8 Bridge Construction Project in Bojonegoro Regency using the crashing method in the form of secondary data. Secondary data is data obtained from relevant agencies in the form of cost budget plans (RAB), S curves, work progress reports & time schedules or all data containing time variables and cost variables for data processing.

Data analysis is a process that does things such as checking, cleaning, transforming, and also modeling data with the aim of being able to find useful information and to inform a conclusion that supports in making it. The data analysis techniques in this study are in the form of steps or flows to compile a thesis on this research are as follows:

a. Data Processing to Know Critical Path

Critical path analysis is used to estimate the duration of work items on a project displayed in the form of a project network diagram. The critical path is the longest network path of activity that determines the fastest time of project completion and has minimum slack or float. Critical path analysis in this study was carried out using the help of the Microsoft Project application.

b. Application of time acceleration or crashing methods

The cost and time analysis techniques for the Kapas Glendeng 8 Bridge construction project in Bojonegoro Regency using the crashing method are as follows:

1. Calculate the required amount of labor under normal conditions.
2. Calculating labor wage requirements under normal conditions.
3. Normal daily productivity
4. Calculate the required number of workers per day.

5. Calculating daily labor wage requirement.
6. Calculating productivity with acceleration
7. Crash Duration
8. Total cost per day
9. Cost Slop

c. Result Analysis

Analyze the results of this study by calculating the cost and time of project work using the crashing method. In this crashing analysis with the change in project completion time, the costs will also change. If the implementation time is accelerated, the direct cost of the project will increase and the indirect cost of the project will decrease There are several ways that can be used to accelerate the completion of project time. One of these ways is by increasing the number of working hours (overtime work).

3. ANALYSIS AND DISCUSSION

3.1. Time Schedule

Time Schedule or project scheduling for the construction of the Kapas - Glendeng 8 Bridge in Bojonegoro Regency is attached to the back of this study.

3.2. Cost Budget Plan

To analyze project costs, the Microsoft Excel 2016 program is used and to determine changes in project costs before and after acceleration, the data entered into Microsoft Excel 2016 is required, namely:

1. Labor wage data for each job.
2. Data on the price of materials and materials for each job.

The following are some of the data needed in this study, starting from the data on the Recapitulation of the Cost Budget Plan (RAB) to the Basic Unit Price of the Kapas-Glendeng Bridge Construction Project 8 Kab. Bojonegoro.

Table 1. Recapitulation of Budget Plan

No. Division	Description	Total Price Bid (Rp.)
DIV. 1	General	Rp. 76.295.000,00
DIV. 2	(Smkk)	Rp. 54.020.000,00
DIV. 4	Earthworks And Geosynthetics	Rp. 45.613.989,19
DIV. 6	Graded Pavement	Rp. 20.888.649,53
DIV. 7	Asphalt Pavement	Rp. 30.013.800,00
DIV. 8	Structure	Rp. 2.274.319.568,04
DIV. 9	Bridge Rehabilitation	Rp. 39.191.843,21
DIV. 10	Daily Work & Miscellaneous Work	Rp. 8.239.140,6
(A)	(Amount)	Rp. 2.548.581.990,63
(B)	PPN = 11 % x (A)	Rp. 280.344.018,97
(C)	**Total Price**	**Rp. 2.828.926.009,60**

Source: Secondary Data Research CV. Merdeka; 2023

3.3. Kristis Path

After obtaining secondary data in the form of implementation time or what is commonly referred to as a time schedule, as well as a Cost Budget Plan (RAB), the next step is to process the data. Data processing is carried out using the Microsoft project program application to determine the critical trajectory or trajectory where there are activities that take the longest time on the Kapas Bridge Construction project - Glendeng 8 Bojonegoro Regency. From the data analysis using the critical trajectory obtained in the Kapas Bridge Construction project - Glendeng 8. Among the critical trajectories in the Kapas-Glendeng 8 bridge construction project in Bojonegoro Regency are as follows:

Table 2. Critical Path Analysis Using Microsoft Project

No	Work Items
1	Stepping Plate (BJTP 280 Plain Reinforced Steel)
2	Decorative painting of concrete structural elements, 100 µm thick
3	Guiding Stake

Source: Research data processing; 2023

3.4. Calculation of Normal Cost and Normal Duration

Normal cost is the total cost of each work activity. Normal cost is used to determine the direct cost coefficient of tools, materials and wages. While the normal duration or normal time is the time it takes to complete the project listed on the project time schedule.

To find out the normal cost or normal cost of each job on the critical path, the first step needs to know the coefficient of each item on the work unit price list. So secondary data is taken in the form of a list of unit prices of work for three work items on the critical trajectory that have been summarized in table 4.2 above. The following is a list of unit prices of work for which normal cost will be sought.

1. **Stepping Plate Work**

Table 3. Below Is an Analysis of The Work Unit Price List For The Soaring Plate (BJTP 280 Plain Reinforcement Steel)

Table 3 List of Unit Prices for Stepping Plate Work

NO.	KOMPONEN		SATUAN	PERKIRAAN KUANTITAS	HARGA SATUAN (Rp.)	JUMLAH HARGA (Rp.)
A.	TENAGA					
1,	Pekerja Biasa	(L01)	jam	0,1050	10642,86	1117,5003
2,	Tukang	(L02)	jam	0,0350	13200	462
3,	Mandor	(L03)	jam	0,0350	15528,57	543,49995
	JUMLAH HARGA TENAGA					2.123,00
B.	BAHAN					
1,	Baja Tulangan Polos BjTP 280	M173	Kg	1,0300	9500	9785
2,	Kawat Beton	M14	Kg	0,0200	22000	440
	JUMLAH HARGA BAHAN					10225
C.	PERALATAN					
1,	Alat Bantu		Ls	1,0000	7451,705633	7451,705633
	JUMLAH HARGA PERALATAN					7451,705633
D.	JUMLAH HARGA TENAGA, BAHAN DAN PERALATAN (A + B + C)					19.799,71
E.	OVERHEAD & PROFIT		10,0	% x D		
F.	HARGA SATUAN PEKERJAAN (D + E)					19.799,71

Source: Secondary Data CV. Merdeka; 2023

Based on the table of unit price list of Soaring Plate work (BJTP 280 Plain Reinforcing Steel) above, the normal cost for labor wages, material costs and equipment costs for Soaring Plate work is as follows:

Wage coefficient = Wage cost / (Wage cost + materials + equipment)
= 2.123,00 / 19.799,71
= 0,1073

Total normal cost = Coef. Wages x Normal cost x Volume of Work Wages
= 0.1073 x 19,799.71 x 997.9
= Rp. 2,118,541.95

Material coefficient = Material cost / (Wage cost + material + equipment)
= 10.225,00/ 19.799,71
= 0,52

Total normal cost = Coef. material x Normal cost x Volume of Work Material
= 0.52 x 19,799.71 x 997.9
= Rp. 10,203,527.5

Tool coefficient = Tool cost / (Wage cost + materials + equipment)
= 7451,71 / 19.799,71
= 0,38

Total normal cost = Coef. tool x Normal cost x Volume of Work Tool
= 0.38 x 19,799.71 x 997.9
= Rp 7,436,057.052

Total normal cost = Total normal cost of wages + Total normal cost of materials + Total normal cost of tools
= Rp. 2,118,541.95 + Rp. 10,203,527.5 +Rp. 7,436,057.052
= Rp 19,758,126.50

2. Decorative Painting of Concrete Structural Elements, 100 µm Thick

Table 4. below is an analysis of the unit price list for Decorative Painting on concrete structural elements, 100 µm thick.

Table 4. Decorative Painting Unit Price List

NO.	KOMPONEN		$ATUAN	PERKIRAAN KUANTITA$	HARGA $ATUAN (Rp.)	JUMLAH HARGA (Rp.)
A.	TENAGA					
1.	Pekerja	(L01)	OH	0,0200	10642,86	212,8572
2.	Tukang	(L02	OH	0,0830	13200	831,6
3.	Mandor	(L03)	OH	0,0030	15528,57	46,58571
	JUMLAH HARGA TENAGA					1091,04291
B.	BAHAN					
1.	Bahan/Material Cat Dasar		Kg	0,2000	66000	13200
2.	Cat Penutup		Kg	0,2600	66000	17160
3	Tiner		Ltr	0,2000	26000	5200
	-					
	JUMLAH HARGA BAHAN					35560
C.	PERALATAN					
1						
2						
	JUMLAH HARGA PERALATAN					0
D.	JUMLAH HARGA TENAGA, BAHAN DAN PERALATAN (A + B + C)					Rp 36.651,04
E.	OVERHEAD & PROFIT		10,0 % x D			Rp 3.665,10
F.	HARGA SATUAN PEKERJAAN (D + E)					Rp 40.316,15

Source: Secondary Data CV. Merdeka; 2023

Based on the work unit price list table above, the normal cost for Decorative Painting on concrete structural elements:

Wage coefficient = Wage cost/ (Wage cost + Material cost)
= 1.091,043/ 36.651,04
= 0,030

Total normal cost = Coef. Wages x Normal cost x Volume of Work Wages
= ,030 x 40,316.15 x 120.97
= Rp. 145,181,807

Material coefficient = Material cost / (Wage cost + Material cost)
= 35,560.00 / 36,651.04
= 0,97

Total normal cost = Coef. material x Normal cost x Volume of Work Materials
= 0.1341 x 40,316.15 x 120.97
= Rp.4,731,862,520

3. Guidepost Work

Table 5 below is the unit price of directional stakes work.

Table 5. Unit Price List of Directional Stakes Work

ITEM PEMBAYARAN NO. : 10.2 (5)
JENIS PEKERJAAN : Patok Pengarah
SATUAN PEMBAYARAN : Kg

NO.	KOMPONEN		SATUAN	PERKIRAAN KUANTITAS	HARGA SATUAN (Rp.)	JUMLAH HARGA (Rp.)
A.	TENAGA					
1.	Pekerja	(L01)	jam	0.6741	10642.86	7174.351926
2.	Tukang	(L02)	jam	0.0899	13200	1186.68
3.	Mandor	(L03)	jam	0,0449	15528,57	697,232793
	JUMLAH HARGA TENAGA					9058,264719
B.	BAHAN					
1.	Beton fc 20 Mpa	M186	M3	0,0618	800000	49440
2.	Baja Tulangan	M173	Kg	5,4270	9500	51556,5
3.	Cat	M42	Kg	0,1000	66000	6600
	JUMLAH HARGA BAHAN					107596,5
C.	PERALATAN					
1.	Dump Truck	E08	Jam	0.0449	253000	11359.7
2	Alat Bantu		Ls	1,0000	7451,705633	7451,705633
	JUMLAH HARGA PERALATAN					18811,40563
D.	JUMLAH HARGA TENAGA, BAHAN DAN PERALATAN (A + B + C)					Rp 135.466,17
E.	OVERHEAD & PROFIT		10,0 % x D			Rp 13.546,62
F.	HARGA SATUAN PEKERJAAN (D + E)					Rp 149.012,79

Source: Secondary Data CV. Merdeka; 2023

Wage coefficient = Wage cost/ (Wage cost + Material cost + Tool cost)
= Rp. 9,058.27/ Rp. 135,466.17
= 0,07

Total normal cost = Coef. Wages x Normal cost x Volume of Work Wages
= 0.07 x 149,012.79 x 11
= Rp. 109,605.00

Tool coefficient = Tool cost/ (Wage cost + Material cost + Tool cost)
= Rp. 18,811.41 / Rp. 135,466.17
= 0,014

Total normal cost = Coef. tool x Normal cost x Work Volume Tool
= 0.014 x 149,012.79 x 11
= Rp. 227,618.00

Material coefficient = Material cost/ (Wage cost + Material cost + Tool cost)
= Rp. 10,7596.5/ Rp. 135,466.17
= 0,79

Total normal cost = Coef. material x Normal cost x Volume of Work material
= 0.79 x 149,012.79 x 11
= Rp. 1,301,917.65

Based on Perpres 70/2012 regarding the profit of service providers is 0-20%, so in this study the profit value is taken at 10% profit and overhead is taken at 5% of the project value. Then the overhead value of the project per day can be found in the following way.

Total project cost = Rp. 2,548,581,990.63

Profit = Total Project Cost x 10%
= Rp. 2,548,581,990.63 x 10%
= Rp. 254,858,199.06

Overhead = Total Project Cost x 5%
= Rp. 2,548,581,990.63 x 5%
= Rp. 127,429,099.53

Project Duration = 180 calendar days
Overhead per day = Overhead
Project Duration = Rp. 127,429,099.53180
= Rp. 707,939.44

After obtaining the overhead cost per day, all the costs of the project can be calculated.

1) *Indirect cost* = *Overhead + profit*
= Rp. 127.429.099,53 + Rp. 254.858.199,06
= Rp. 382.287.298,60

2) *Direct Cost* = 85% x Total Biaya Proyek
= 85% x Rp. 2.548.581.990,63
= Rp. 2.166.294.692,04

3.5. Calculation of Normal Cost and Normal Duration

The following is the calculation of the required amount of labor (Coefficient) on the work of Soaring Plate (BJTP 280 Plain Reinforced Steel).

1. Coefficient Requirement for Stepping Plate Work (Plain Reinforcing Steel)

   Work Volume = 997.9 Kg

   a. Coefficient of Labor for Soaring Plate (BJTP 280 Plain Reinforcing Steel)

      Worker = 0.1050
      Handyman = 0.0350
      Foreman = 0.0350
      The coefficient value is obtained based on AHSP 2022.

   b. Wages

      Worker = Rp. 85,000.00 per day
      Handyman = Rp. 105,000.00 per day
      Foreman = Rp. 125,000.00 per day

2. Analysis of Stepping Plate Work Recourse Needs

   a. Number of workers required = Volume x Coefficient
      = 997,9 x 0,1050
      = 104 people

   b. Number of masons required = Volume x Coefficient

= 997,9 x 0,0350
= 35 People

a. Number of foremen required = Volume x Coefficient
= 997,9 x 0,0350
= 35 People

3. Price of Wages for Stepping Plate Work (BJTP 280 Plain Reinforcing Steel)
a. Worker Wage Price = Number of Workers x Wage
= 104 x Rp. 85,000.00
= Rp. 8,840,000.00

a. Wage Price of Builders = Number of Builders x Wage
= 35 x Rp. 105,000.00
= Rp. 3,675,000.00

b. Foreman Wage Price = Number of Foremen x Wages
= 35 x Rp. 125,000
= Rp. 4,375,000.00

3.6. Kebutuhan Koefisien Pada Pekerjaan Pengecatan Dekoratif

The following is the calculation of the number of labor requirements (Coefficient) on structural work, namely Decorative Painting work.

1. Coefficient requirement for decorative painting work.
Work Volume = 120.97 m2
a. Labor Coefficient
Worker = 0.020
Handyman = 0.063
Foreman = 0.003
Coefficient value obtained based on AHSP 2022

b. Wages
Worker = Rp. 85,000.00 per day
Handyman = Rp. 105,000.00 per day
Foreman = Rp. 125,000.00 per day

2. Analysis of Recourse Requirements for Decorative Painting Work.
a. Number of workers = Volume x Coefficient
= 120,97 x 0.020
= 3 people

b. Number of masons = Volume x Coefficient

= 120,97 x 0.063
= 8 People

c. Number of foremen = Volume x Coefficient
= 120,97 x 0.003
= 1 Person

3. Price of wages for decorative painting work.
a. Worker Wage Price = Number of Workers x Wage
= 3 x Rp. 85,000
= Rp. 255,000.00

b. Handyman Wage Price = Number of Handyman x Wage
= 8 x Rp. 105,000
= Rp. 840,000.00

d. Foreman Wage Price = Number of Foremen x Wages
= 1 x Rp. 125,000.00
= Rp. 125,000.00

3.7. Coefficient Requirement on Guiding Stakes

The following is a calculation of the number of labor requirements (Coefficient) on the work of directional stakes.

1. Coefficient Requirement for Directional Stake Work.

Work Volume = 11 m'
Labor Coefficient
Worker = 0.6741
Handyman = 0.0899
Foreman = 0.0449
The coefficient value is obtained based on AHSP 2022.

2. Analysis of Recourse Requirement for Directional Stake Work.
a. Number of workers = Volume x Coefficient
= 11 x 0,6741
= 8 people

b. Number of masons = Volume x Coefficient
= 11 x 0,0899
= 1 Person

c. Number of foremen = Volume x Coefficient
= 11 x 0,0449
= 1 Person

3. Price of wages for painting work
   a. Worker Wage Price = Number of Workers x Wage
      = 8 x Rp. 85,000.00
      = Rp. 680,000

   b. Handyman Wage Price = Number of Handyman x Wage
      = 1 x Rp. 105,000.00
      = Rp. 105,000

   c. Foreman Wage Price = Number of Foremen x Wages
      = 1 x Rp. 125,000.00
      = Rp. 125,000.00

3.8. Labor Productivity Analysis

Labor productivity per day is used to find the amount of labor required on jobs that are on the critical path, Labor productivity.

1. Labor productivity on plain iron stepping plate work

   Worker = $\frac{997,9}{104}$ = 9.59 Kg/day

   Worker = $\frac{997.9}{35}$ = 28.51 Kg/day

   Foreman = $\frac{997.9}{35}$ = 28.51 Kg/day

2. Labor productivity on decorative painting work

   Worker = $\frac{120.97}{3}$ = 40.32 m2/day

   Handyman = $\frac{120.97}{8}$ = 15.12 m2/day

   Foreman = $\frac{120.97}{1}$ = 120.97 m2/day

3. Labor productivity on the work of the Directional Stake

   Worker = $\frac{11}{8}$ = 1.375 m/day

   Worker = $\frac{11}{1}$ = 11.00 m/day

   Foreman = $\frac{11}{1}$ = 11.00 m/day

3.9. Determining the Number of Workers Per Day

1. Number of manpower per day on plain iron stepping plate work

   Volume = 997.9 Kg
   Duration = 9 days

   Workers = $\frac{997.9}{9{,}59 \text{ x } 9}$ = 12 OH

   Handyman = $\frac{997.9}{28{,}51 \text{ x } 9}$ = 4 OH

   Foreman = $\frac{997.9}{28{,}51 \text{ x } 9}$ = 4 OH

2. Total labor per day on Decorative Painting work

   Volume = 120.97 m2
   Duration = 3 days

   Workers = $\frac{120.97}{40{,}32 \text{ x } 3}$ = 1 OH

   Handyman = $\frac{120.97}{15{,}12 \text{ x } 3}$ = 3 OH

   Foreman = $\frac{120.97}{120{,}97 \text{ x } 3}$ = 1 OH

3. Total labor per day on the work of directional stakes

   Volume = 11 m
   Duration = 6 days

   Workers = $\frac{11}{1{,}375 \text{ x } 6}$ = 1 OH

   Handyman = $\frac{11}{11 \text{ x } 6}$ = 1 OH

   Foreman = $\frac{11}{11 \text{ x } 6}$ = 1 OH

3.10. Calculating Wages Per Day Resource on Normal Work

1. Plain Iron Stepping Plate work wage BJTP 280

   Wages per day:
   Workers = 12 x Rp. 85,000.00 = Rp. 1,020,000.00
   Handyman = 4 x Rp. 105,000.00 = Rp. 420,000.00
   Foreman = 4 x Rp. 125,000.00 = Rp. 500,000.00 +
   Rp. 1.940.000,00

2. Wages for Decorative Painting work

Wages per day:
Worker = 1 x Rp. 85,000.00 = Rp. 85,000.00
Handyman = 3 x Rp. 105,000.00 = Rp. 315,000.00
Foreman = 1 x Rp. 125,000.00 = Rp. 125,000.00 +
Rp. 525,000.00

3. Wages for the work of directional stakes

Wages per day:
Worker = 1 x Rp. 85,000.00 = Rp. 85,000.00
Handyman = 1 x Rp. 105,000.00 = Rp. 105,000.00
Foreman = 1 x Rp. 125.000,00 = Rp. 125.000,00 +
Rp. 315.000,00

3.11. Cost and Duration Acceleration Calculation

The productivity of each worker per day is already known from previous analysis with the duration of normal working hours is 8 hours per day. So for the next step, the duration of accelerated crashing will be calculated by increasing working hours by four hours per day by considering the decrease in labor productivity during overtime hours.

1. Determine labor productivity after adding four working hours. The project used working hours per day is 8 hours/day.

Table 6. Recapitulation of Labor Productivity Overtime Hours

No	Description	Unit	Workers	Builder	Foreman
1	Plain Iron Stepping Plate BJTP 80	Kg	12,465	37,061	37,061
2	Decorative painting of concrete structural elements	m2	52,416	19,656	157,26
3	Guiding Stake	m	1,788	14,30	14,30

Source: Research data processing; 2023

2. Determine The Duration After Adding Four Hours of Overtime

After getting the labor productivity value of overtime hours, then look for the duration of work after being accelerated.

a. BJTP 80 Plain Iron Stepping Plate Work

$$\text{Workers} = \frac{997.9}{12{,}465 \text{ x } 12} = 6.67 \text{ days}$$

Handyman = $\frac{997.9}{37,061 \text{ x } 4}$ = 6.73 days

Foreman = $\frac{997.9}{37,061 \text{ x } 4}$ = 6.73 days

So, from the results of the above calculations, an average of 6.711 is obtained and rounded up to 7 days.

b. Decorative painting work on concrete structural elements.

Worker = $\frac{120.97}{52.416 \text{ x } 1}$ = 2.308 days

Handyman = $\frac{120.97}{19,656 \text{ x } 3}$ = 2,051 days

Foreman = $\frac{120.97}{157,26 \text{ x } 1}$ = 0.769 days

So, from the above results, an average of 1.709 is obtained and rounded up to 2 days.

c. Work of directional stakes

Workers = $\frac{11}{1,788 \text{ x } 1}$ = 6.152 days

Workers = $\frac{11}{14,3 \text{ x } 1}$ = 0.769 days

Foreman = $\frac{11}{14,3 \text{ x } 1}$ = 0.769 days

So, it can be averaged and rounded to 3 days.

3. Determine Additional Costs And Total Labor Costs

After obtaining the accelerated work duration, it can be calculated how much additional costs due to additional working hours using a formula based on the provisions written in the decision of the Minister of Labor Number KEP.102/MEN/VI/2004 article 11 concerning overtime working hour wages.

Table 7. Recapitulation of Total Labor Wages Plus Four Hours of Work

No	Description	Total Labor Wage plus four hours	*Cost Slop* Total
1	Reinforcement of BJTP 280 Plain Iron Stepping Plate	27.709.479,77	10.249.479,78

2	Decrative Painting of Concrete Structural Elements	2.142.485,55	567.485,55
3	Guiding Stake	1.928.236,99	38.236,99
	TOTAL	31.780.202,31	10.855.202,32

Source: Research data analysis; 2023

3.12. Calculation Analysis

After acceleration using an increase in working hours, direct costs will increase while indirect costs will decrease. In this study, the amount of overhead and profit is taken 15% of the RAB. Based on Perpres 70/2012, the profit of service providers is 0-15%. In Perpres 54/2010 as amended by Perpres 70/2012, Paragraph on Price Adjustment Article 92 paragraph 3 that in adjusting the price to determine the Fixed Coefficient consisting of profit and overhead if the offer does not include the amount of the profit and overhead components, the Fixed Coefficient is 15%. This means that the calculation of profit in the provider's bid price is left to the provider. Unless the provider does not include it, only a conclusion of 15% is taken. The difference in cost between the normal situation and after acceleration is as follows:

Project RAB value = Rp. 2,548,581,990.63

Overhead and Profit = Total Project Cost x 15%
= Rp. 2,548,581,990.63 x 15%
= Rp. 382,287,298.59

Profit 10% = Project RAB Value x 10%
= Rp. 2,548,581,990.63 x 10%
= Rp. 254,858,199.06

Overhead 5% = RAB Project Value x 5%
= Rp. 2,548,581,990.63 x 5%
= Rp. 127,429,099.53

3.13. Project Cost in Accelerated Condition

The following below is a recapitulation table of duration and cost comparisons between normal projects (normal cost and normal duration) and the duration and cost of projects that have been accelerated (normal cost and normal duration):

Table 8. Recapitulation of Time and Cost Comparison

Project Time	Direct Cost	Indirect Cost	Total Cost
Normal Time	2.166.294.692,04	382.287.298,60	2.548.581.990,64
Overtime	2.177.149.894,36	378.039.661,62	2.555.189.555,98
Difference	10.855.202,32	4.247.636,98	6.607.565,34

Source: Research data analysis; 2023

3.14. Discussion

From the results of the calculation analysis as above, the Kapas Bridge Construction project - Glendeng 8 Bojonegoro Regency is planned to be completed within 180 calendar days starting on June 25, 2023 will be completed on December 22, 2023 with a work Budget Plan of Rp. 2,548,581,990.63 Accelerating the project duration by adding a four-hour overtime working hour method to the late work will increase the direct cost of the project and will reduce the indirect cost of the project. In this study, the amount of overhead and profit is taken as 15% of the Cost Budget Plan, then the overhead cost per day will be obtained.

From the cost analysis, the accelerated time required to complete the project is 174 calendar days or 0.97% faster than the normal duration of 180 calendar days. But the direct cost has increased from the original cost of Rp. 2,166,294,692.04 to Rp. 2,177,149,894.36 or an increase of about 1.005% from direct costs at normal working time, by accelerating the duration, indirect costs will decrease from Rp. 382,287,298.60 to Rp. 378,039,661.62 or a decrease of 0.99% from indirect costs on normal work. The results of this analysis show that the addition of four hours of overtime work caused the total project cost to increase from Rp. 2,548,581,990.64 to 2,555,189,555.98.

Based on the discussion above, several results were obtained. First, there are advantages and disadvantages in using the system of adding four hours of overtime. The advantages are:

1. Accelerate project duration.
2. Reduced project duration effectively.
3. Avoid over time.

While the disadvantages are:

1. For the company, there will be additional wage expenditures.
2. Wages for four-hour overtime workers who are outside normal working hours can be higher.
3. It is possible that the performance of workers outside normal working hours is not as optimal as workers in normal working hours.
4. Increased risk of work accidents.

To carry out overtime system work / additional working hours must pay attention to possible conditions, such as:

1. Availability of labor.

In general, the labor required for overtime system work must be available and cannot be lacking. This condition clearly affects the system because if there is no labor, it is certainly impossible to carry out overtime system work. And if the planned number is insufficient, the work certainly cannot run smoothly and according to the target.

2. Project site conditions

The location of the building has an important impact on the timing of project implementation, because the location of the project has an impact on the availability of resources such as materials, tools and time.

3. Material readiness

Material is the building material. Therefore, optimal management is required. Material management is an activity that includes the functions of planning needs, determining budgets, selecting sources, transporting, storing, and monitoring goods optimally because materials are very important needs in the success of a construction project. By controlling construction materials in accordance with the necessary needs we will be able to provide benefits in many ways, including increasing labor productivity, preventing material loss, labor efficiency, and preventing negative cash flow. The shifting system is highly dependent on material readiness. In order for the work to be carried out smoothly without experiencing obstacles in terms of material procurement, material procurement must be carried out in an effective and efficient manner. Effective procurement relates to accuracy in quality, quantity, time, price, material source, and delivery location.

4. Possible work sequences

This sequence of work is related to scheduling. In scheduling, each activity must estimate the duration considered based on the type of work, volume of work, number of resources, work environment, and worker productivity. In performing the shift system, the flow prioritizes critical or near-critical activities with maximum resources (capable of being crashed) and the lowest total float. If the availability of resources is limited and their availability is not sufficient, the project duration will be slower than planned. So that the crash will not have an impact.

4. CONCLUSION

There are also the following conclusions:

1. Work items that are on the critical trajectory in the Kapas-Glendeng 8 Bridge construction project in Bojonegoro Regency are the work item for reinforcing the stepping plate with BJTP 280 plain iron, the work item for directional stakes and the work item for decorative painting on concrete structural elements, 100 µm thick.
2. The impact caused by changes in time on this cost is the increase in the amount of direct costs which originally amounted to Rp. 2,166,294,692.04 in 180 calendar days of work to Rp. 2,177,149,894.36 in 174 days with a difference of Rp. 10,855,202.32 or an increase of about 1.005%. Meanwhile, because the duration of the project after crashing is shortened, it causes a decrease in indirect costs (Indirect cost) which was originally Rp. 382,287,298.60 to Rp. 378,039,661.62 with a difference of Rp. 4,247,636.98 or a decrease of 0.99%. The increase in direct costs and the reduction in indirect costs caused the total cost of the project to also change from Rp. 2,548,581,990.64 to Rp. 2,555,189,555.98 with a difference of Rp. 6,607,565.34. In this study, the authors found that the total cost of crashing turned out to be more expensive, which increased by 1.005% compared to the total cost when normal.

ADVICE

Based on the results of the research that has been carried out and the conclusions above, the authors provide the following suggestions:

1. In order for a project to run according to plan and on schedule, the following steps should be taken:
   a. Time efficiency in project implementation.
   b. Addition of overtime working hours.
   c. Addition of labor.
   d. Addition of tools.
   e. Addition of work groups/time or with work shifts.
2. For further research related to accelerating project duration using overtime working hours carried out only on critical activities or should be done from the beginning of the work including work on non-critical activities.
3. This research may be an option for consideration to the contractor to accelerate the project with the overtime hour method in the next project.

REFERENCES

Budianto, E. A., & Husin, A. E. (2021). Analisis Optimasi Waktu Dan Biaya Dengan Metode Time Cost Trade Off Pada Proyek Gudang Amunisi. Jurnal Aplikasi Teknik Sipil, 19(3), 305–310.

Irawan, Y. A., & Juara, A. (2022). Analisa Optimasi Biaya Dan Waktu Metode TCTO (Time Cost Trade Off)(Study Kasus: Preservasi Jalan Ruas Sp. Gunung Kemala–Sanggi). Jurnal Civil Engineering Study, 2(02), 60–66.

Kementerian Pekerjaan Umum [PU]. (2016). Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 28. PRT/M/2016 Tentang Pedoman Analisis Harga Satuan Pekerjaan Bidang Pekerjaan ….

Muhyi, A. (2018). Percepatan Proyek Menggunakan Metode Time Cost Trade Off Pada Proyek Jembatan Krueng Tingkeum Kabupaten Bireuen. Prosiding Seminar Nasional Politeknik Negeri Lhokseumawe, 2(1).

Rosyid, R., Sarya, G., Beatrix, M., & Oetomo, W. (2020). Studi Analisis Biaya Dan Waktu Menggunakan Metode Time Cost Trade Off (Tcto) Pada Proyek Telkom Manyar-Surabaya. Extrapolasi, 17(1), 20–29.

Wardana, Z. R., & Putra, I. N. D. P. (2023). Analisis Percepatan Proyek Menggunakan Metode Fast Track DAN Metode Crashing Pada Proyek Pembangunan Gedung Bertingkat. Cived, 10(2), 491–500.

Wijanarko, B., & Oetomo, W. (2019). Analisis Percepatan Waktu Penyelesaian Proyek Dengan Metode Crashing Dan Fast Tracking Pada Pelebaran Jalan Dan Jembatan'. Jurnal Untag__.

Yaqin, H. N., Tjendani, H. T., & Witjaksana, B. (2023). Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method. Devotion Journal of Community Service, 4(2), 336–346.

Zuhriyah, A., & Oetomo, W. (2022). Analisis Percepatan Waktu Dengan Metode Fast Track Dan Crashing Pada Proyek Pt Graynenda Putra Karya. Jurnal Kacapuri: Jurnal Keilmuan Teknik Sipil, 5(1), 341–350.

Copyrights