

**ACCELERATION STUDY WITH CRASHING METHOD ON THE
LONG SEGMENT HANDLING SUPERVISION PROJECT
(ROUTINE MAINTENANCE, PERIODIC MAINTENANCE,
IMPROVEMENT/RECONSTRUCTION) OF THE HANDIL JAWA
– JAMBU BURUNG (DAK) ROAD**

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ABSTRACT

In a project, the most influential thing on the success or failure of the project is time and budget. In the Long Segment Handling Supervision Project (Routine Maintenance, Periodic Maintenance, Improvement/Reconstruction) of the Handil Jawa – Jambu Burung Road (DAK), Banjar Regency experienced a delay in project work. So that it was accelerated using *Crashing*.

In this study, *crashing* with overtime (additional working hours) was used and calculated late fines on the project. By accelerating activities that are experiencing critical paths.

The results of this study were obtained that the total cost was carried out *crashing* with the method of adding 4 working hours with a duration of 162 and still experiencing delays for 12 days with a total cost of Rp. 10,100,506,276.77. Meanwhile, the total acceleration was not carried out by experiencing a delay of 16 days of Rp.10,056,662,598.08. Therefore, the results obtained are *crashing* with an additional 4 hours of efficient and optimal work in total costs.

Keywords: Project delays, *Crashing*, increased working hours (overtime).

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1. INTRODUCTION

Scheduling is essential in a project to ensure that the project can be completed on time, at the right cost and of great quality. In a project there will be delays if scheduling is not managed properly which leads to increased costs. Scheduling is a problem that needs to be managed well, as project owners need the right schedule to complete the project on time.

In this project, there was a delay deviation of -0.17% in week 3, -0.70% in week 4, -0.97% in week 5, -0.46% in week 8 and -4.64% in week 9, therefore an acceleration was carried out. The project is accelerated to address the decline in progress on this project due to the difference between the realization weight and the plan weight during the work and becomes an implementation study for future projects.

In this study do a time acceleration analysis, that way you will know how fast you can accelerate at the optimal cost and you can quickly overcome any delays.

2. THEORETICAL FOUNDATION

Scheduling

According to Ervianto (2002), Scheduling is the process of determining the order of activities, the time needed, and how quickly the project can be completed. Project scheduling is a step-by-step plan created to achieve project goals with planned completion.

Work Breakdown Structure (WBS)

Work Breakdown Structure is a structured diagram that resembles a tree structure diagram. WBS is used to break down each work process into more detail, with the aim of improving the accuracy of project planning.

Precedence Diagram Method (PDM)

PDM is a network of work that uses activity within nodes (AON), with arrows indicating the relationships between nodes. Unlike CPM and PERT, the PDM method can explain the dependencies between activities such as SS, SF, FS, and FF.

Crashing Method

Crashing is a systematic, analytical, and targeted testing process to test all project activities, with an emphasis on activities on critical paths, to reduce project completion time.

Acceleration With Alternative Increase of Working Hours (Overtime)

Adding extra working hours to a project is one way to speed up project completion. This addition is very common because it uses existing resources on site and saves contractor costs. .(Nissa, Priyo, & Widiati, 2016)

The calculation of overtime wages according to Government Regulation of the Republic of Indonesia No. 35 of 2021 concerning Overtime Wages Article 31 and Article 32 paragraphs 1 and 2, is as follows:

$$1. \text{ Daily productivity} = \frac{\text{Volume}}{\text{Durasi normal}} \dots\dots\dots (1)$$

$$2. \text{ Productivity per hour} = \frac{\text{Produktivitas harian}}{\text{Jam kerja perhari}} \dots\dots\dots (2)$$

$$3. \text{ Daily productivity after Crash} = (\text{Hours worked per day} \times \text{Productivity per hour}) + (\text{a} \times \text{b} \times \text{Productivity per hour}) \dots\dots\dots (3)$$

With:

a = length of additional working hours (overtime)

b = coefficient of decrease in productivity

The result of the increase in working hours (overtime) The value of the productivity decrease coefficient can be seen in the Table

$$4. \text{ Crash duration} = \frac{\text{Volume}}{\text{Produktivitas harian sesudah crash}} \dots\dots\dots (4)$$

Table 2. 1 Coefficient Decreased Productivity

Overtime Hours	Decrease in Productivity Index	Work Performance (%)
1 Hour	0,1	90
2 Hours	0,2	80
3 Hours	0,3	70
4 Hours	0,4	60

To calculate additional costs for overtime based on the "Decree of the Minister of Manpower and Transmigration of the Republic of Indonesia Number KEP. 102/MEN/VI/2004" as follows:

$$1. \text{ Normal cost of workers per day} = \text{Daily productivity} \times \text{Unit price of workers' wages.} \dots\dots\dots (6)$$

$$2. \text{ Normal hourly labor rate} = \text{Hourly productivity} \times \text{Unit price of labor wage} \dots\dots\dots (7)$$

3. Workers' overtime costs = $1.5 \times \text{normal hourly wage for the first additional working hours (overtime)} + 2 \times n \times \text{normal hourly wage for the next additional working hours (overtime)}$ (8)

With:

n = total additional working hours (overtime)

4. *Crash cost* Employees per day = $(\text{Hours worked per day} \times \text{Normal Cost workers}) + (n \times \text{Hourly overtime costs})$ (9)

5. *Cost slope* = $\frac{\text{crash cost} - \text{Normal cost}}{\text{Durasi normal} - \text{Durasi crash}}$ (10)

(Nissa, Priyo, & Widiyanti, 2016)

3. METHOD

This Final Project discusses the problem of optimal time analysis in a project that occurs late by accelerating the duration of the project or by the *Crashing* method in the Supervision of Long Segment Handling of Jalan Handil Jawa – Jambu Burung, Banjar Regency.

The location of this research was carried out in the Long Segment Handling Supervision Project of Jalan Handil Jawa – Jambu Burung (DAK), which is located in the Banjar Regency area.

Data Collection

The data information used is:

1. Primary Data
 - Field condition data
 - Employee working hours
 - Interview
2. Secondary Data
 - *Time Schedule/S-Curve*
 - Cost Budget Plan (RAB)
 - Volume of Work Items
 - Employee Unit Price
 -

Data Analysis

Data analysis using *Crashing* as follows

1. Collect data – project data
2. Identify activities
3. Determine the level of work
4. Develop a logical sequence of work and relationships between jobs
5. Creating *Network Planning* with PDM (*Precedence Diagramming Method*)
6. Determine activities that are on a critical trajectory.
7. Calculate time acceleration by adding working hours (overtime)
8. Calculate *Crash duration* by adding 1 hour, 2 hours, 3 hours and 4 hours.
9. Calculate the cost of increasing the increase in working hours
10. Calculating *the Cost Slope*
11. Crash *the Program* from the *smallest Cost Slope* number
12. Calculate the direct and indirect costs of the project before crashing.
13. Calculating the total cost of the project after *crashing* with overtime (additional working hours).

4. RESULTS AND DISCUSSION

Work Breakdown Structure (WBS)

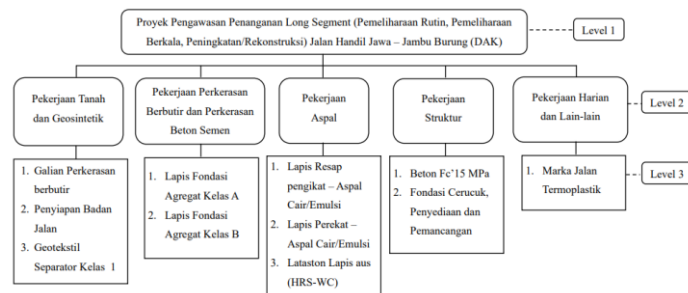


Figure 4. 2 WBS Supervision Project for Handling Long Segment Jalan Handil Jawa – Jambu Burung (DAK)

Analysis of Dependency Relationships Between Workers

Relationship of Dependency Between Jobs In construction projects, some work may start and be completed at the same time, while some work may start a few days after the other work is completed.

Table 4. 4 Relationship Between Jobs

No.	Work	Duration (days)	Dependency Relationships	Predecessor
1	Pile Foundation, Preparation and Piling	85	START	
2	Stone Pairs	39	SS5	Pile Foundation, Preparation and Piling
3	Quarrying Granular Pavement	61	SS15	Stone Pairs
4	Road Body Preparation	61	SS1	Quarrying Granular Pavement
5	Geotextile Separator Class 1	61	SS3	Road Body Preparation
6	Class B Aggregate Foundation Layer	77	SS3	Geotextile Separator Class 1
7	Class A Aggregate Foundation Layer	61	SS21	Class B Aggregate Foundation Layer
8	Binding Diffusion Coating - Molten Asphalt/Emulsion	70	SS15	Class A Aggregate Foundation Layer
9	Adhesive Coating - Liquid Asphalt/Emulsion	70	SS	Binding Diffusion Coating - Molten Asphalt/Emulsion
10	Lataston Lapis Aus (HRS-WC)	70	SS	Adhesive Coating - Liquid Asphalt/Emulsion
11	Concrete Fe' 15 Mpa	62	SS29	Lataston Lapis Aus (HRS-WC)
12	Thermoplastic Road Markings	15	SS60	Concrete Fe' 15 Mpa

Precedence Diagram Method

After making the analysis of the dependency logic can then be created, a Precedence Diagram Method (PDM) is used to find the work items on the critical path.

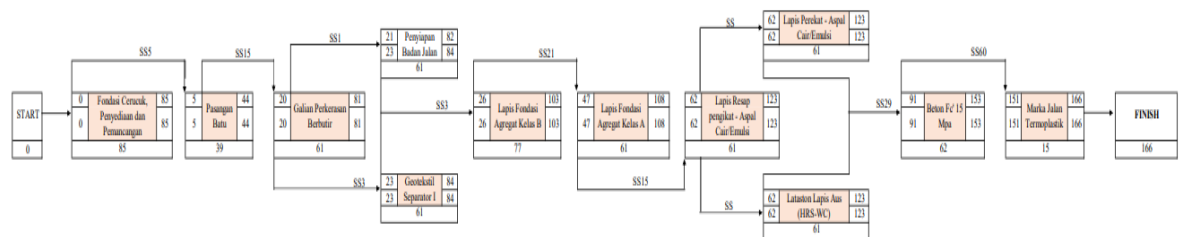


Figure 4. 4 PDM Supervision Project for Handling Long Segment Jalan Handil Jawa – Jambu Burung (DAK)

Acceleration Program when Increasing Working Hours

The stages of calculation are:

Calculating Daily Productivity:

$$\text{Daily productivity} = \frac{\text{volume}}{\text{durasi normal}} = 971.82 \text{ m} \frac{82.604,4 \text{ m}^1}{85 \text{ hari}} / \text{day}$$

Calculating Hourly Productivity:

$$\text{Productivity per hour} = \frac{\text{Produktivitas harian}}{\text{jam kerja perhari}} = 121.48 \text{ m} \frac{971,82 \text{ m}^1/\text{hari}}{8 \text{ jam}} / \text{h}$$

Calculation of Daily Productivity After Crash (P.H.S.C)

Post-collapse daily productivity is the daily productivity achieved after the collapse schedule; Normal working hours are 8 hours per day, with adjustable overtime hours from 1 to 4 hours. Calculation for the addition of 1 hour of overtime:

$$\begin{aligned} \text{P.H.S.C} &= (8 \text{ jam} \times 121,48 \text{ m}^1/\text{jam}) + (1 \text{ jam} \times 0,9 \times 121,48 \text{ m}^1/\text{jam}) \\ &= 1081,15 \text{ m}^1/\text{day} \end{aligned}$$

Calculating Crash Duration

Calculation for the addition of 1 hour of overtime:

$$\text{Crash Duration} = \frac{\text{Volume}}{\text{Produktivitas Harian Sesudah Crash}} = 76,40 \text{ days} \frac{82.604,4 \text{ m}^2}{1081,15 \text{ m}^1/\text{hari}} \approx$$

The following shows the table of the results of the acceleration calculation by adding working hours for various activities in the Long Segment Handling Supervision Project of Jalan Handil Jawa – Jambu Burung (DAK), Banjar Regency.

Table 4. 7 Acceleration Calculation Results with Increased Working Hours

No.	Work	Duration (Days)	Volume	Unit	Daily Productivity	Daily Productivity Per Hour	1 Overtime Hours		2 Overtime Hours		3 Overtime Hours		4 Jam Lembur	
							Productivity After Crash	Crash Durations	Productivity After Crash	Crash Durations	Productivity After Crash	Crash Durations	Produktivitas Sesudah Crash	Crash Durations
1.	Pile Foundation, Preparation and Piling	85	82604,4	m ³	971,82	121,48	1081,15	76,40	1166,18	70,83	1226,92	67,33	1263,36	65,38
2.	Stone Pairs	39	187,3	m ³	4,80	0,60	5,34	35,06	5,76	32,50	6,06	30,89	6,24	30,00
3.	Quarrying Granular Pavement	61	337,6	m ²	5,53	0,69	6,16	54,83	6,64	50,83	6,99	48,32	7,19	46,92
5.	Geotextile Separator Class I	61	4974,0	m ²	81,54	10,19	90,71	54,83	97,85	50,83	102,95	48,32	106,00	46,92
6.	Class B Aggregate Foundation Layer	77	497,4	m ²	6,46	0,81	7,19	69,21	7,75	64,17	8,16	60,99	8,40	59,23
7.	Class A Aggregate Foundation Layer	61	1169,8	m ²	19,18	2,40	21,33	54,83	23,01	50,83	24,21	48,32	24,93	46,92
8.	Binding Diffusion Coating - Molten Asphalt/Emission	61	5292,6	Liter	86,76	10,85	96,52	54,83	104,12	50,83	109,54	48,32	112,79	46,92
9.	Adhesive Coating - Liquid Asphalt/Emission	61	3217,2	Liter	52,74	6,59	58,67	54,83	63,29	50,83	66,59	48,32	68,56	46,92
10.	Lataton Lapis Atas (HRS-WC)	61	2451,7	Ton	40,19	5,02	44,71	54,83	48,23	50,83	50,74	48,32	52,25	46,92
11.	Concrete Fc' 15 Mpa	62	959,2	m ³	15,47	1,93	17,21	55,73	18,57	51,67	19,53	49,11	20,11	47,69
12.	Thermoplastic Road Markings	15	218,1	m ²	14,54	1,82	16,18	13,48	17,45	12,50	18,36	11,88	18,90	11,54

Cost Acceleration by Increasing Working Time

Normal Hourly Wage :

$$\text{Foreman} = \frac{\text{Rp.175.000,00}}{8 \text{ jam}} = \text{Rp. 21,875.00}$$

$$\text{Craftsman} = \frac{\text{Rp.143.500,00}}{8 \text{ jam}} = \text{Rp. 17,937.50}$$

$$\text{Worker} = \frac{\text{Rp.131.313,00}}{8 \text{ jam}} = \text{Rp. 16,414.13}$$

Employee Overtime Costs:

$$\text{Foreman} = 1 \times (1,5 \times \text{Rp.21.875,00}) + (2 \times 1 \text{ hour} \times \text{Rp.21,875.00}) = \text{Rp. 76,562.50}$$

$$\text{Craftsman} = 2 \times (1,5 \times \text{Rp.17,937,50}) + (2 \times 1 \text{ hour} \times \text{Rp.17,937.50}) = \text{Rp. 125,562.50}$$

$$\begin{aligned} \text{Worker} &= 2 \times (1,5 \times \text{Rp.17,937,50}) + (2 \times 1 \text{ hour} \times \text{Rp.17,937.50}) = \text{Rp.} \\ &114,898.88 \end{aligned}$$

$$\text{Total cost} = \text{Rp. 317,023.88}$$

$$\text{Normal Cost} = \text{Rp. 1,054,969,703.94}$$

$$\begin{aligned}\text{Crash Cost} &= \text{Normal Cost} + \text{Total Cost} = \text{Rp. } 1,054,969,703.94 + \text{Rp. } 317,023.88 \\ &= \text{IDR } 1,055,286,727.82\end{aligned}$$

$$\text{Normal Duration} = 85 \text{ days}$$

$$\text{Crash Duration} = 76 \text{ days}$$

$$\begin{aligned}\text{Cost Slope} &= \frac{\text{Rp. } 1,055,286,727.82 - \text{Rp. } 1,054,969,703.94}{85 \text{ hari} - 76 \text{ hari}} \\ &= \text{Rp. } 35,224.88\end{aligned}$$

Table 4. 1 Value *Cost Slope* Addition of Overtime Hours

No.	Work	Normal Cost	Normal Duration	Cost Slope 1 Jam	Cost Slope 2 Jam	Cost Slope 3 Jam	Cost Slope 4 jam
1.	Pile Foundation, Preparation and Piling	Rp 1.054.969.703,94	85	Rp 35.224,88	Rp 35.584,31	Rp 37.740,94	Rp 43.024,67
3.	Quarrying Granular Pavement	Rp 14.253.542,90	61	Rp 121.269,90	Rp114.340,19	Rp119.937,26	Rp141.069,06
4.	Road Body Preparation	Rp 15.865.471,09	61	Rp 31.910,23	Rp 30.086,79	Rp 31.559,57	Rp 37.120,06
5.	Geotextile Separator Class 1	Rp 140.496.598,80	61	Rp 89.359,67	Rp 84.253,40	Rp 88.377,69	Rp103.949,00
6.	Class B Aggregate Foundation Layer	Rp 281.985.888,62	77	Rp 59.838,57	Rp 57.865,87	Rp 64.112,75	Rp 72.186,21
7.	Class A Aggregate Foundation Layer	Rp 670.318.784,30	61	Rp 79.784,76	Rp 75.225,63	Rp 78.908,00	Rp 92.810,84
8.	Binding Diffusion Coating - Molten Asphalt/Emulsion	Rp 130.844.556,94	61	Rp 70.209,85	Rp 66.197,86	Rp 69.438,32	Rp 81.672,69
9.	Adhesive Coating - Liquid Asphalt/Emulsion	Rp 81.862.651,33	61	Rp 51.060,04	Rp 48.142,33	Rp 50.498,94	Rp 59.396,38
10.	Lataston Lapis Aus (HRS-WC)	Rp 4.681.638.856,12	61	Rp 102.120,08	Rp 96.284,65	Rp100.997,88	Rp118.792,75
11.	Concrete Fe' 15 Mpa	Rp 1.631.145.747,79	62	Rp 71.987,13	Rp 67.873,58	Rp 71.196,06	Rp 83.740,13
12.	Thermoplastic Road Markings	Rp 36.947.492,72	15	Rp 304.801,44	Rp478.973,69	Rp435.430,63	Rp413.659,09

Program Crash Calculation

The *Crash Program* is implemented by adding overtime time to project work based on the order of the smallest to largest cost slope.

Crash Program with an Addition of 1 Hour – 4 Working Hours, for an Increase of 1 Hour – 3 Hours of Work, 4 times of acceleration by accelerating the part of the work item that gets the lowest *cost slope value*. The total duration of the IV acceleration results was 164 days and did not change the critical path for an additional 1 working hour, 164 days and did not change the critical path for an additional 2 working hours and 163 days and did not change the critical path for an additional 3 working hours. Meanwhile, the addition of 4 hours of work is only done 1 acceleration with a total duration of 162 days and does not change the critical path.

Determination of Project Cost Planning

Table 4. 2 Total Cost Calculation

		Duration	Direct Costs	Indirect Costs	Total Cost
Normal	150		Rp8.917.378.341,20	Rp 980.911.617,53	Rp 9.898.289.958,74
1 Hour	Acceleration I	166	Rp8.917.941.939,20	Rp 1.085.542.190,07	Rp 10.003.484.129,27
	Acceleration II	166	Rp8.920.527.473,20	Rp 1.085.542.190,07	Rp 10.006.069.663,27
	Acceleration III	166	Rp8.919.318.659,54	Rp 1.085.542.190,07	Rp 10.004.860.849,61
	Acceleration IV	164	Rp8.921.645.561,33	Rp 1.072.463.368,50	Rp 9.994.108.929,83
2 Hour	Acceleration I	166	Rp8.917.947.690,20	Rp 1.085.542.190,07	Rp 10.003.489.880,27
	Acceleration II	166	Rp8.920.677.431,87	Rp 1.085.542.190,07	Rp 10.006.219.621,94
	Acceleration III	166	Rp8.919.207.784,20	Rp 1.085.542.190,07	Rp 10.004.749.974,27
	Acceleration IV	164	Rp8.924.083.972,83	Rp 1.072.463.368,50	Rp 9.996.547.341,33
3 Hour	Acceleration I	166	Rp8.917.982.196,20	Rp 1.085.542.190,07	Rp 10.003.524.386,27
	Acceleration II	166	Rp8.920.752.411,20	Rp 1.085.542.190,07	Rp 10.006.294.601,27
	Acceleration III	166	Rp8.919.297.337,36	Rp 1.085.542.190,07	Rp 10.004.839.527,43
	Acceleration IV	163	Rp8.923.038.939,33	Rp 1.065.923.957,72	Rp 9.988.962.897,05
4 Hour	Acceleration I	162	Rp8.922.342.250,33	Rp 1.059.384.546,93	Rp 9.981.726.797,26

Minimum Cost Analysis

The minimum cost analysis is used to compare the cost of paying the fine with the most efficient acceleration cost.

- Late Fine Fee

The cost of the project penalty is an additional fee imposed if the project is not completed on time according to the deadline set in the contract between the project owner and the contractor. With a delay of 16 days, a fee of Rp. 10,056,662,598.08 will be obtained.

- Cost in addition to 4 hours of work

In this calculation, a total duration of 162 days was obtained and still experienced a delay of 12 days from normal time. Total cost of Rp. 10,100,506,276.77

5. CONCLUSION

Based on the results of the research that has been carried out using the Crashing method in this project, conclusions can be drawn, namely:

1. In the Long Segment Handling Supervision project (Routine Maintenance, Periodic Maintenance, Improvement/Reconstruction) of Jalan Handil Jawa – Jambu Burung Burung (DAK), Banjar Regency is planned to be completed within a duration of 150 calendar days. This study accelerated the duration of the project on critical trajectories by adding 1 to 4 hours of overtime. The results of this study analysis

show that the total effective time of accelerating the project with an additional 4 hours of overtime is 162 days, 4 days shorter than the time of field work, but there is still a delay of 12 days.

2. The total cost for the normal duration of the project before the acceleration is Rp. 9,898,289,958.74, the total cost of Acceleration by adding 4 hours of overtime and late fines is Rp. 10,100,506,276.77 and the total cost if a fine is imposed is Rp. 10,056,662,598.08. So it can be concluded that the optimal cost is taken at the total cost if a late fine of Rp. 10,056,662,598.08 is applied

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