

TIME AND COST OPTIMIZATION IN LIANG ANGGANG – MARTAPURA – BTS ROAD PRESERVATION PROJECT RANTAU CITY

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ABSTRACT

Liang Anggang – Martapura – Bts. Kota Rantau Road Preservation Project, at the request of the PUPR Ministry as the owner, conveyed to the service provider contractor PT. Kelana Multi Konstruksi to accelerate the work process so that it can be used as a land facility connecting one area to another so that as construction management it is very necessary to optimize time and costs in its work. Work assessment can be done using the Earned Value Management (EVM) method. where to improve the performance, optimization is carried out with the Crashing Program.

The method in this study to determine the performance of the project, the EVM method is used by calculating the BCWS, BCWP and ACWP indicators, then calculating the Performance Analysis (CV, SV, CPI, and SPI), calculating the Estimate To Complete (ETC) value, calculating the Estimate At Completion (EAC) value, and calculating the Time Estimated (TE). Then to prevent inefficiency in the project, time and cost optimization is carried out where the calculation begins by finding the critical path using Microsoft Project 2016 then the Crashing Program is carried out by adding 2 alternatives in the form of additional working hours and additional labor so that the most optimal cost addition value is obtained at the end of the project.

The results of this research analysis obtained a project cost performance index of $CPI\ 1.027 > 1$, which means that project performance shows that the cost expenditure is smaller than the budget, while the results of the SPI schedule performance index are $0.946 < 1$, which means that project performance shows that the implementation time is late from the planned schedule. The estimated cost to be incurred in the 22nd week (EAC) is IDR 10,301,128,358 if the project performance trend is the same as the performance in the 22nd week, then the estimated remaining work cost (ETC) is IDR 3,344,776,378. Judging from the project completion time, an estimated time of 35.93 weeks was obtained where the project completion was 1.93 weeks slower than the planned 34 weeks. Based on the results of research that has been conducted on the acceleration process of the Liang Anggang - Martapura - Bts. Kota Rantau Road Preservation project, it can be concluded that the crash program with the addition of 1 hour of work on thermoplastic road marking work has more optimal results. Because the total cost is smaller, namely Rp 9,080,322,187.08 with a duration of 241 days which has exceeded the normal duration.

Keywords: Earned Value Management, Critical Path, Crashing Program

1. INTRODUCTION

In the reviewed project, namely the Liang Anggang - Martapura - Bts. Kota Rantau Road Preservation Package Project, which is the focus program of the PUPR Ministry to handle roads in the area after the floods that hit South Kalimantan. In carrying out the project, various obstacles were encountered due to weather and equipment damage as well as limited availability and mobility of workers due to the applicable PPKM policy.

In addition, the Liang Anggang – Martapura – Bts. Kota Rantau Road Preservation Project at the request of the PUPR Ministry as the owner conveyed to the service provider contractor PT. Kelana Multi Konstruksi to accelerate the work process so that it can be used as a land facility connecting one area to another so that as construction management it is very necessary to optimize time and costs in its work. Work assessment can be carried out using the Earned Value Management (EVM) method where to improve performance, optimization is carried out with the Crashing Program. As an effort to minimize costs and time in accelerating scheduling.

2. THEORETICAL BASIS

Construction Project Management

Construction project management is a method to achieve a result in the form of a building or infrastructure that is limited by time by using existing resources effectively. The need for construction project management as an organization of construction project work in scheduling and financing can be done well when in the field so that completion

Earned Value Management Method

Earned Value Management method provides information on how the project is performing in a construction activity, so that corrective measures can be taken if there is a deviation from the initial project plan. The Earned Value Management method provides information on the estimated completion time and costs for project work needs based on the project performance indicator report. So it is expected that the use of the Earned Value Management method on the project can be in accordance with the budgeted budget and completed on time.

Microsoft Project

Microsoft Project is a software program specifically designed for project management, developed and sold by Microsoft. Microsoft Project itself is designed to

help a Project Manager in his work in the field of construction projects to be more effective and efficient.

Time and Cost Optimization

Optimization is a process of accelerating the duration of a project to obtain optimal results effectively and efficiently using the cost aspect that is reviewed as an alternative. Accelerating project completion is an effort to complete a project earlier than the completion time under normal circumstances. The process of accelerating the completion time of a project is called a Crash Program . By holding this project acceleration, there will be a reduction in the duration of activities in the activities for which the Crash Program will be held . However, there is a time limit for acceleration (crash duration), which is a limit where the reduction in time beyond this time limit will no longer be effective.

3. METHOD

The stages carried out in this research are as follows:

1. Determining the research object to be carried out
2. Collecting, reading and studying literature books, research reports and scientific papers related to Project Performance (Earned Value) and Time and Cost Optimization (Crash Program).
3. Summarizes theories related to Project Performance (Earned Value Management) and Time and Cost Optimization (Crash Program).
4. Conducting data collection and processing to assist in research.
5. Conducting a data analysis, namely:
 - Calculating project performance based on time and cost using the Earned Value Management method.
 - Calculating time and cost optimization with Crash Program
6. Determine conclusions and suggestions

4. RESULTS AND DISCUSSION

Earned Value Management Method

Earned Value Management method was carried out in the 22nd week.

1. Budgeted Cost Of Work Schedule (BCWS) Calculation

$$BCWS = \text{Planned weight} \times BAC = 71.36\% \times \text{Rp } 10,574,719,200 = \text{Rp } 7,546,395,462$$

2. Budgeted Cost Of Work Performance (BCWP) Calculation

$$BCWP = \text{Realized weight} \times BAC = 67.53\% \times \text{Rp } 10,574,719,200 = \text{Rp } 7,141,107,876$$

3. Actual Cost Work Performance (ACWP) Calculation

$$\begin{aligned} ACWP &= \text{Direct Cost} + \text{Indirect Cost} \\ &= \text{Rp. } 6,069,941,694.40 + \text{Rp. } 886,410,286 \\ &= \text{Rp. } 6,956,351,980.28 \end{aligned}$$

4. Calculation of Variance and Performance Index

$$SV = BCWP - BCWS = \text{Rp } 7,141,107,876 - \text{Rp } 7,546,395,462 = - \text{Rp } 405,287,586$$

$$CV = BCWP - ACWP = \text{Rp } 7,141,107,876 - \text{Rp } 6,956,351,980.28 = \text{Rp } 184,755,895.72$$

5. Performance Index Calculation

$$SPI = BCWP / BCWS = \text{IDR } 7,141,107,876 / \text{IDR } 7,546,395,462 = 0.946$$

$$CPI = BCWP / ACWP = \text{Rp } 7,141,107,876 / \text{Rp } 6,956,351,980 = 1.027$$

6. Estimated Cost Calculation and Final Project Schedule

$$\begin{aligned} ETC &= (BAC - BCWP) / CPI \\ &= (\text{Rp } 10,574,719,200 - 7,141,107,876) / 1.027 \\ &= \text{Rp. } 3,344,776,378 \end{aligned}$$

$$\begin{aligned} EAC &= ACWP + ETC \\ &= \text{Rp } 6,956,351,980 + \text{Rp } 3,344,776,378 \\ &= \text{Rp. } 10,301,128,358 \end{aligned}$$

$$\begin{aligned} TE &= ATE + (OD - (ATE \times SPI)) / SPI \\ &= 22 + (34 - (22 \times 0.946)) / 0.946 \\ &= 35.93 \text{ weeks} \end{aligned}$$

Earned Value Method calculation for the 22nd week can be seen in Table 1 below:

Table 1 Earned Value Management Method Calculation Week 22

Indeks	Minggu ke-22	
BCWS	Rp	7,546,395,462
BCWP	Rp	7,141,107,876
ACWP	Rp	6,956,351,980
SV	-Rp	405,287,586
CV	Rp	184,755,895
SPI		0.946
CPI		1.027
ETC	Rp	3,344,776,378
EAC	Rp	10,301,128,358
TE	Rp	35.93

From the values in Table 1. it can be seen that the BCWP value is below BCWS, resulting in a negative SV value indicating that the work is being done later than the schedule. While the ACWP value is much smaller than the BCWP value, resulting in a positive CV value, indicating that the costs incurred are much less than the budgeted costs. It can be seen that the SV value is IDR -405,287,586 and the CV value is IDR 184,755,895 so that the work costs less than the budget and the work is slower than the planned schedule.

For CPI index = 1.027 and SPI index = 0.946, so the expenditure is less than the budget and the implementation time is slower than the planned schedule. For the estimated cost of completing the EAC project is: Rp 10,301,128,358 while ETC or estimated cost of completion for the remaining work is Rp 3,344,776,378. The difference in the calculation of the completion time from the 4th week to the 22nd week is $34 - 35.93 = -1.93$ so it can be concluded that there is a 2-week delay and optimization will be carried out.

Crashing Program

1. Determining Normal Cost and Normal Duration

In this project based on the results of interviews with contractors, direct costs are 85% of the price of each work item and indirect costs are 15% of the total construction cost. For the duration of the project based on the work contract, it is 260 calendar days.

2. Determining the Critical Path

Based on the input results with Microsoft Project 2016, 3 activity items were obtained which were on the critical path. The critical path analysis can be seen in Table 2. below:

Table 2 Critical Path

Code	Job Description	Duration (Days)
51	Thermoplastic road marking	168
60	Class A aggregate base layer repair	132
63	Hot mix cold asphalt repair	195

3. Crashing When Working Hours Are Added

The following is an example of calculations for thermoplastic road marking work:

$$\text{Daily Productivity} = \frac{\text{Volume}}{\text{Durasi Normal}} = \frac{1044}{168} = 6.21 \text{ m}^2/\text{day}$$

$$\text{Hourly Productivity} = \frac{\text{Produktivitas harian}}{\text{Jam Kerja Normal}} = \frac{6,21}{7} = 0.89 \text{ m}^2/\text{hour}$$

$$\text{Productivity 1 Hour} = \frac{\text{Produktivitas normal perjam}}{\text{indeks lembur 1 jam}} = \frac{0,89 \text{ m}^2/\text{jam/unit}}{1,1} = 0.81 \text{ m}^2/\text{hour/unit}$$

$$\text{Tool effectiveness} = \frac{\text{Produktivitas lembur 1 jam}}{\text{produktivitas normal 1 jam}} \times 100 = \frac{0,89}{0,81} \times 100 = 90.91\%$$

$$\text{Crash Duration (DC)} = \frac{D_n \times h}{(h + (h_o \times e))} = \frac{168 \times 7}{(7 + (1 \times 0,91))} = 148.69 \text{ days} \approx 149 \text{ days}$$

The results of the crash duration calculation can be seen in Table 3.

Table 3 Crash Duration During Overtime 1 Hour, 2 Hours, 3 Hours and 4 Hours

Job Description	Volume	Unit	Duration (Days) (nd)	Crash Duration (CD) during overtime			
				1 Hour	2 Hours	3 Hours	4 Hours
Thermoplastic road marking	1044	M2	168	112	84	68	56
Class A aggregate base layer repair	3064.37	M3	138	131	124	118	112
Hot mix cold asphalt repair	345.6	M3	195	174	156	142	130

Example of calculation of overtime wages for the 1st hour

$$\text{Workers} = \text{Rp. } 17,857.14 \times 1.5 = \text{Rp. } 26,785.71$$

$$\text{Handyman} = \text{Rp. } 22,857.14 \times 1.5 = \text{Rp. } 34,285.71$$

$$\text{Foreman} = \text{Rp. } 25,714.29 \times 1.5 = \text{Rp. } 38,571.43$$

$$\text{Compressor} = \text{Rp } 219,765.17 + (1.5 \times (28,571.43 + 21,368.71)) = \text{Rp } 294,675.38$$

$$\text{Dump Truck} = \text{Rp } 579,614.88 + (1.5 \times (28,571.43 + 21,368.71)) = \text{Rp } 654,525.09$$

Based on the calculation of the wage price, the wage price data is input into the unit price analysis for 1 hour of overtime and the price obtained is Rp. 214,494,341.40.

$$\begin{aligned} \text{Cost Slope} &= \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Duration} - \text{Crash Duration}} = \frac{\text{Rp } 214,494,341.40 - \text{Rp } 212,593,530.60}{168 - 149} \\ &= \text{Rp. } 100,042.67 \end{aligned}$$

The results of the cost slope calculation for adding overtime hours can be seen in Table 4.

Table 4 Cost Slope Overtime 1 Hour, 2 Hours, 3 Hours and 4 Hours

Job Description	Cost Slope			
	1 Hour	2 Hours	3 Hours	4 Hours
Thermoplastic road marking	Rp 100,042.67	Rp 288,055.42	Rp 382,600.00	Rp 438,716.91
Class A aggregate base layer repair	Rp 6,586,628.38	Rp 18,295,997.00	Rp 1,000,000.00	Rp 27,571,690.45
Hot mix cold asphalt repair	Rp 902,377.31	Rp 2,612,144.84	Rp 2,153,846.15	Rp 3,905,370.65

4. Crash program at the time of adding workers

The following is an example of calculations for thermoplastic road marking work:

$$\text{Daily Productivity} = \frac{\text{Volume}}{\text{Durasi Normal}} = \frac{1044}{168} = 6.21 \text{ m}^2/\text{day}$$

$$\text{PSOP} = \frac{\text{Produktivitas Harian}}{\text{Jumlah tenaga kerja}} = \frac{6.21}{2} = 3.11 \text{ m}^3/\text{day/person}$$

$$\begin{aligned} \text{PHSC} &= (\text{PSOP} \times (\text{Number of workers} + \text{additional workers})) \\ &= (3.11 \times (2 + 1)) = 9.32 \text{ m}^3/\text{day} \end{aligned}$$

$$\text{Crash Duration} = \frac{\text{Volume}}{\text{P.H.S.C}} = \frac{1044}{9.32} = 112 \text{ hari}$$

The results of the crash duration calculation can be seen in Table 5.

Table 5. Crash Duration Added 1 Workforce, 2 Workforces, 3 Workforces and 4 Workforces

Job Description	Volume	Unit	Duration (Days) (nd)	Crash Duration (CD) during overtime			
				1 Workforce	2 Workforce	3 Workforce	4 Workforce
Thermoplastic road marking	1044	M2	168	112	84	68	56
Class A aggregate base layer repair	3064.37	M3	138	131	124	118	112
Hot mix cold asphalt repair	345.6	M3	195	174	156	142	130

$$\begin{aligned} \text{Crash Cost} &= \text{Normal Cost} + (\text{Cost of Additional Workers} \times \text{Crash Duration}) \\ &= \text{Rp } 212,593,530.60 + ((160,000 \times 1) \times 112) \\ &= \text{Rp. } 230,513,530.60 \end{aligned}$$

$$\begin{aligned} \text{Cost Slope} &= \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Duration} - \text{Crash Duration}} \\ &= \frac{\text{Rp } 230,513,530.60 - \text{Rp } 212,593,530.60}{168 - 112} = \text{Rp. } 330,000.00 \end{aligned}$$

The results of the cost slope calculation for adding workers can be seen in Table 6.

Table 6. Cost Slope of Addition of 1 Worker, 2 Workers, 3 Workers and 4 Workers

Job Description	Cost Slope			
	1 Workforce	2 Workforce	3 Workforce	4 Workforce
Thermoplastic road marking	Rp 330,000.00	Rp 330,000.00	Rp 326,400.00	Rp 382,600.00
Class A aggregate base layer repair	Rp 2,339,285.71	Rp 2,214,285.71	Rp 2,212,500.00	Rp 2,153,846.15
Hot mix cold asphalt repair	Rp 1,035,714.29	Rp 1,000,000.00	Rp 1,004,716.98	Rp 1,000,000.00

5. Time and Acceleration Cost Calculation

After calculating the crash duration and cost slope, the next step is the crashing process by looking at the smallest slope value on the critical path in the network as the starting point of the crashing process. In this acceleration, the accelerated activity starts from the smallest cost slope, namely the thermoplastic road marking work.

1. Calculation of time and cost of accelerated working hours

$$\begin{aligned}
 \text{Project Duration} &= \text{Normal Duration} - \text{Acceleration Time} \\
 &= 260 \text{ days} - 19 \text{ days} = 241 \text{ days} \\
 \text{Cost} &= \text{Project Cost} + (\text{acceleration time} \times \text{cost slope}) \\
 &= \text{Rp } 9,079,304,363.64 + (19 \times \text{Rp } 100,042.67) \\
 &= \text{Rp } 9,080,322,187.08
 \end{aligned}$$

2. Calculation of time and cost of labor acceleration

$$\begin{aligned}
 \text{Project Duration} &= \text{Normal Duration} - \text{Acceleration Time} \\
 &= 260 \text{ days} - 56 \text{ days} = 204 \text{ days} \\
 \text{Cost} &= \text{Project Cost} + (\text{acceleration time} \times \text{cost slope}) \\
 &= \text{Rp } 9,079,304,363.64 + (56 \times \text{Rp } 320,000.00) \\
 &= \text{Rp } 9,096,341,376.28
 \end{aligned}$$

Based on the results of Earned Value Management, it was found that there was a project delay of 2 weeks so that the acceleration results of adding 1 working hour and 1 labor on the smallest cost slope, namely on thermoplastic road marking work, have been fulfilled. For other work on the critical path, acceleration is not carried out because it will only increase the cost of implementation and the duration of the project that was delayed can return to normal duration.

6. Discussion

From the results of the crashing calculations that have been carried out, it can be seen that acceleration by adding working hours (overtime) and labor shows that this alternative can accelerate the duration of the project that is late to the contract duration

but is still unable to return to the initial planned duration of the project so that the project can still be carried out without having to pay a late fine.

Of the two acceleration methods that have been carried out, the acceleration method by adding worker hours to the thermoplastic road marking work is the method with the lowest cost. So the most optimum acceleration method to overcome the delays that occur and can exceed the original duration is acceleration by adding 1 Working Hour to the Thermoplastic Road Marking work.

5. CONCLUSION

Based on the results of calculations and data analysis, the following conclusions can be drawn:

1. Based on the research results of the Liang Anggang – Martapura – Bts. Kota Rantau Road Preservation project that has been carried out, the project cost performance index CPI is $1.027 > 1$, which means that project performance shows that the cost expenditure is smaller than the budget, while the results of the SPI schedule performance index are $0.946 < 1$, which means that project performance shows that the implementation time is late from the planned schedule. The estimated cost to be incurred in the 22nd week (EAC) is IDR 10,301,128,358 if the project performance trend is the same as the performance in the 22nd week, then the estimated remaining work cost (ETC) is IDR 3,344,776,378. Judging from the project completion time, an estimated time of 35.93 weeks is obtained where the project completion is 1.93 weeks slower than the planned 34 weeks.
2. Based on the results of the research that has been conducted on the acceleration process of the Liang Anggang - Martapura - Bts. Kota Rantau Road Preservation project, it can be concluded that the crash program method with the addition of 1 working hour on thermoplastic road marking work has more optimal results. Because the total cost is smaller, namely Rp 9,080,322,187.08 with a duration of 241 days which has exceeded the normal duration.

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