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Optimization Study of Cost and Duration of Project Implementation Case Study: Spillway Construction of Bendo Dam Project

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***Abstract* - Good construction planning is one of the requirements for successful construction. This spillway construction with contract value of IDR99,939,304,966, - was under-schedule so that would affect the rest of the construction costs and duration. Then this study will discuss the optimization of rest costs and duration of this spillway construction. The solution in this study uses trial and error with CPM (Critical Path Method) and will get optimal costs and duration for the rest construction. The rest duration for the initial plan for construction of spillway is 192 days (9 months) with the rest contract cost of IDR46,593,769,076.80. Then control the time and cost of the remaining work using crashing with the method of adding labor and overtime work. A trial and error I result is IDR47,613,769,076.80 and IDR47,260,089,076.80 the efficiency duration is 6 months. Furthermore, trial and error 2 resulted in IDR47,721,769,076.80 and IDR 47,272,969,076.80 with a completion duration in 7 months, next trial and error 3 resulted IDR 46,621,669,076.80 and IDR 46,610,389,076.80 with 8.5 months. From the calculations and graphs of the three trials and errors get the conclusion for optimum cost results are IDR47,760,000,000,- with additional labor and IDR47,300,000,000,- with overtime work methods and the optimum duration is 138 days.**

Keywords: cpm, crashing, optimization, rescheduling.

I. INTRODUCTION

A good construction planning process is one of the requirements for a successful project development. Before the start of the construction process, everything will be planned in detail and everything needed in detail and carefully. Therefore, in the initial stages of planning must have a careful planning schedule and a good construction plan. The source of funds that have been allocated with a normal level of productivity to be solved will also experience problems because if the problem occurs and the project experiences delays, the cost will be even greater.

To restore the level of project progress to the original plan, an effort to shorten the duration of project implementation is needed. The source of funds that have been allocated with a normal level of productivity to be solved will also experience problems because if the problem occurs and the project experiences delays, the cost will be even greater. To restore the level of project progress to the original plan, an effort to shorten the duration of project implementation is needed.

II. METHOD

This study takes data from PT. RAYA CONSULT as the project supervision consultant for the Bendo Bend construction work in Ponorogo. This research uses the Critical Path Method (CPM).

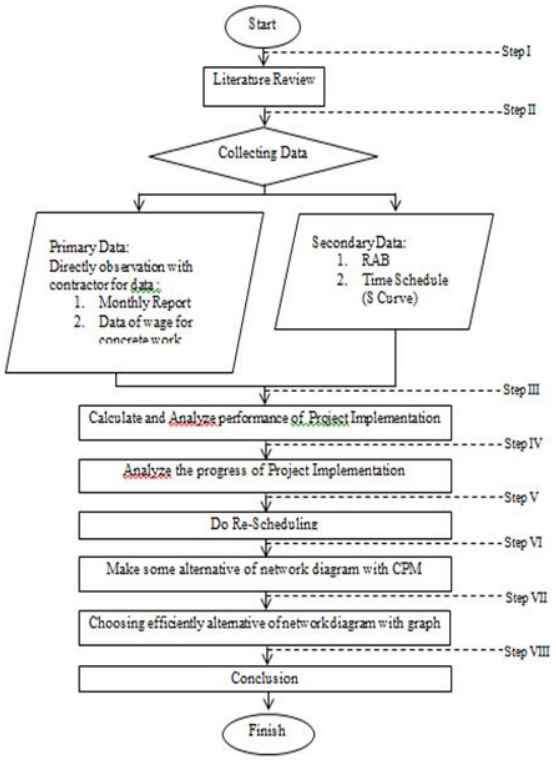

Figure 1: Flowchart Research

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Data collection is divided into two, namely primary data and secondary data. Primary data collection in the form of: monthly reports and concrete work wage data. While secondary data collection is in the form of: cost budget plan (RAB), and time schedule (S curve).

Stages of research are steps that are arranged systematically and logically based on the basic theories that already exist to achieve the objectives of an object problem. The stages of this final project research can be seen in the following research sequence scheme:

III. RESULTS AND DISCUSSIONS

To know the progress of activities, the progress of the work implementation plan is exposed with the realization of work implementation. From this comparison a deviation will be obtained which shows the achievement of an activity. From the display of the "s" curve and table Analysis of the weight of the plan and the realization of the work below can be seen the deviation of the weekly activities so that they can be categorized ahead of schedule, or slower depending on the percentage point of the activity. If the realization point is above, it means that the activity plan is faster than the scheduled schedule, if it is below the activity plan, which is later than the schedule.

From the S curve, planning and realization of the Spillway Construction progress is under schedule.

3.1 Recapitulation of Volume and Remains

The work remaining that has not been realized then made a scheduling model accompanied by network planning. The volume used the remaining volume of the plan.

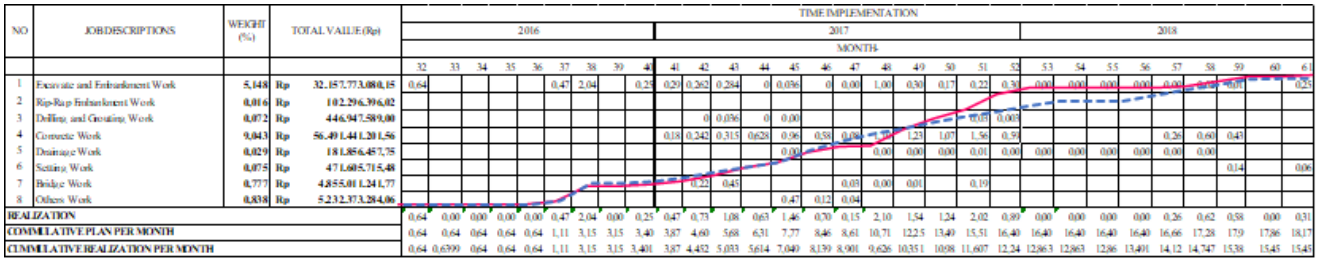

Figure 2: S Curve of Combination

Which, dotted line is realization project and straight line is planning project. It is concluded from the combination of the S curve above that the implementation of the Spillway work is under schedule.

The rescheduling design of the rest of the work and the form of CPM will be made in accordance with the Sub-chapter of the work and there are 7 tracks namely:

a) Excavation and Fill work
b) Drilling and Grouting
c) Concrete works
d) Drainage Work
e) Bridge work
f) Setting work
g) Rip-rap fill work
h) Other Work

TABLE 1
S Curve of the spillway rescheduling

NO	JOB DESCRIPTION	WEIGHT (%)	TOTAL VALUE (Rp)		TIME IMPLEMENTATION								
					2018						2019		
					MONTH-								
					59	60	61	62	63	64	65	66	67
1	Excavate and Embankment Work	0,90079	Rp	5.626.900.682,50	0,90								
2	Rip-Rap Embankment Work	0,01638	Rp	102.296.396,02									0,016
3	Drilling and Grouting Work	0,0274	Rp	171.143.979,50		0,027							
4	Conxrete Work	6,12608	Rp	38.267.438.318,78		0,7658	0,77	0,766	0,77	0,77	0,77	0,77	0,766
5	Drainage Work	0,02788	Rp	174.185.647,75				0,03					
6	Setting Work	0,0755	Rp	471.605.715,48					0,08				
7	Bridge Work	0,07719	Rp	482.198.632,31						0,08			
8	Others Work	0,20779	Rp	1.297.999.704,46						0,1	0,1		
		7,46	Rp	46.593.769.076,80									
TOTAL					0,90	0,79	0,77	0,79	0,84	0,95	0,87	0,77	0,78
TOTAL CUMMULATIVE PER BULAN					0,90	1,69	2,46	3,25	4,09	5,04	5,91	6,68	7,46

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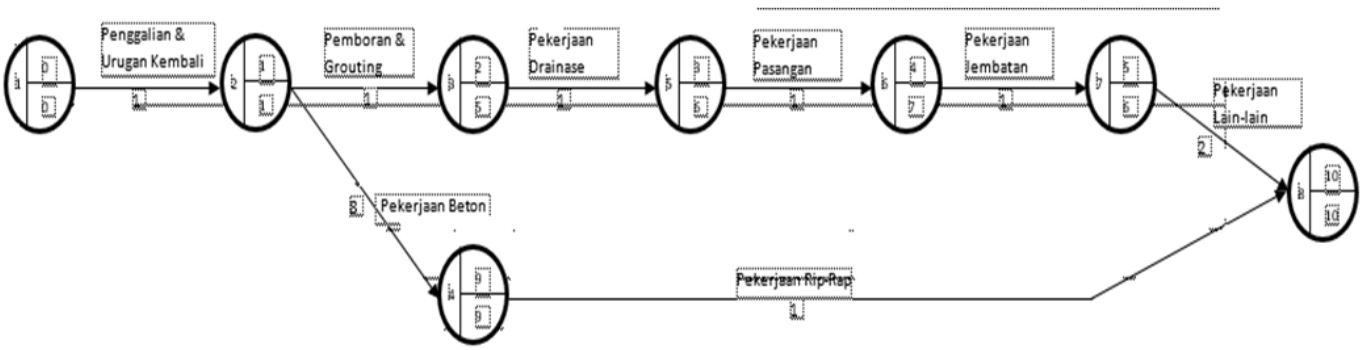

Figure 3: CPM network in Normal Duration

Determining the critical path can be done by knowing the value of EET and LET of an activity.

From the above calculation we get the float value of each activity in the table below with the equation Float = LF – EF.

Critical trajectory is a trajectory along the jarring diagram that has the longest time (project duration) or trajectory through activities that do not have float (pause time).

From the above calculation, we get a critical trajectory in the activities of activity no. 1-2-4-8 namely on the activities:

a) Excavation and back pile
b) Concrete works
c) Rip-rap work

3.2 Trial and Error 1

In this research in carrying out the acceleration of completion of project work using ways to increase the number of overtime work and the addition of the worker. Here are some Trial and errors using the CPM network.

1) Calculation of worker crashing trial and error 1

Concrete work
Volume Planning = 54.539,05 m^3
Normal Duration = 192 days
Crashing Duration = 120 days
Numb. Of worker = 20 people
To complete the work, 0.03 workers are needed
Then 1 worker can complete 1/0,03 = 33,33 m^3/kg
Productivity per hour person = 33,33/7 = 4,762 m^3/kg
The rest of the work will be done by the overtime method or by increasing the number of workers.

With overtime work method

Overtime : 1hour ; 2hour ; 3hour
Productivity decrease : 10% ; 20% ; 30%
Work presentation : 90% ; 80% ; 70%
Planned overtime for 34 people per hour productivity is:
Overtime

1 hour	= 90% x 4,762	= 4,286 x 100	=428,6
2 hour	= 80% x 4,762	= 3,810 x 100	=381,0
		Total	809,6

So to finish the rest of the pitch. Needed :
= 10.623,69 / 809,6 = 67,36
So it takes time = 68 days overtime
Labor = 20
Workman = 12
Foreman = 2
Overseer (Mandor) = 0

By adding the workers

Increase the number of workers to 5 people, so there are 25 workers working.
By using 25 workers, a time of 120 days, duration of 7 hours of work will produce volume
= 50 x 120 x 7 x 4,762
= 100.002 m^3/kg ≠ 45.205,53 m^3/kg
So with the addition of 25 workers can complete the work.
Composition of labor:
Labor = 25
Workman = 12
Foreman = 2
Overseer (Mandor) = 1

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TABLE 2
Rescheduling Trial and Error 1

NO	JOB DESCRIPTION	WEIGHT (%)	TOTAL VALUE (Rp)	TIME IMPLEMENTATION								
				2018						2019		
				MONTH-								
				59	60	61	62	63	64	65	66	67
1	Excavate and Embankment Work	0,90079	Rp 5.626.900.682,50	0,90								
2	Rip-Rap Embankment Work	0,01638	Rp 102.296.396,02									0,016
3	Drilling and Grouting Work	0,0274	Rp 171.143.979,50		0,027							
4	Conxrete Work	6,12608	Rp 38.267.438.318,78			1,23	1,23	1,23	1,23	1,23		
5	Drainage Work	0,02788	Rp 174.185.647,75				0,03					
6	Setting Work	0,0755	Rp 471.605.715,48					0,08				
7	Bridge Work	0,07719	Rp 482.198.632,31						0,08			
8	Others Work	0,20779	Rp 1.297.999.704,46						0,1	0,1		
		7,46	Rp 46.593.769.076,80									
TOTAL				0,90	0,03	1,23	1,26	1,31	1,41	1,33	0,00	0,02
TOTAL CUMMULATIVE PER BULAN				0,90	0,93	2,16	3,42	4,72	6,13	7,47	7,47	7,48

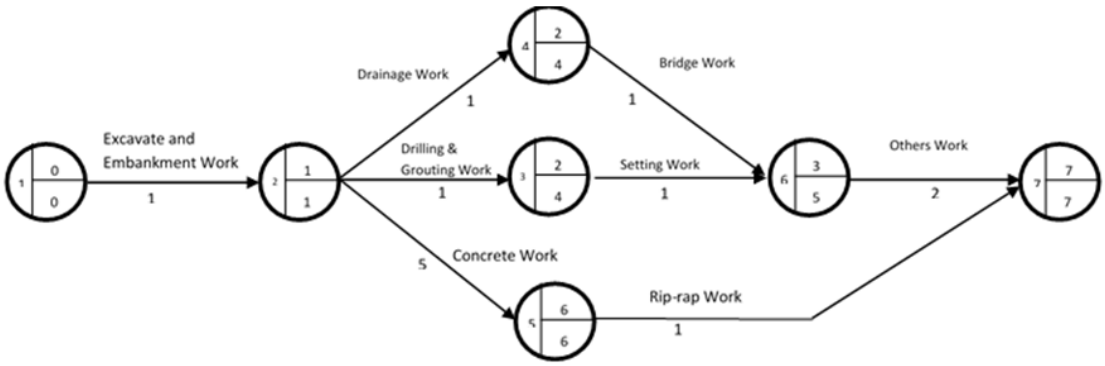

Figure 4: Network Planning CPM for 1st Alternative

2) Cost Calculation of trial and error 1

1. CONCRETE WORK

Explanation		Number		Day		Wages		Total	
Labor	=	20	x	120	x	Rp 100.000	=	Rp	240.000.000
Workman	=	12	x	120	x	Rp 125.000	=	Rp	180.000.000
Foreman	=	2	x	120	x	Rp 150.000	=	Rp	36.000.000
Overxeer	=	1	x	120	x	Rp 200.000	=	Rp	24.000.000
TOTAL							=	Rp	480.000.000

2.A Cost Calculation with Overtime

Overtaime at 1st Hour

Explanation		Number		Day		Wages		Total	
Labor	=	20	x	68	x	Rp 30.000	=	Rp	40.800.000
Workman	=	12	x	68	x	Rp 35.000	=	Rp	28.560.000
Foeman	=	2	x	68	x	Rp 40.000	=	Rp	5.440.000
Overxeer	=	0	x	68	x	Rp 50.000	=	Rp	-
TOTAL							=	Rp	74.800.000

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Overtaime at 2nd Hour

Explanation		Number		Day		Wages		Total	
Labor	=	25	x	68	x	Rp 40.000	=	Rp	68.000.000
Workman	=	12	x	68	x	Rp 45.000	=	Rp	36.720.000
Foeman	=	2	x	68	x	Rp 50.000	=	Rp	6.800.000
Overxeer	=	0	x	68	x	Rp 60.000	=	Rp	-
TOTAL							=	Rp	111.520.000

Total Overtime cost = Rp 186.320.000
Total Cost = (Cost per day + Cost Overtime) = Rp 666.320.000

2.B. Cost Calculation with Adding Workers

Explanation		Number		Day		Wages		Total	
Labor	=	25	x	120	x	Rp 100.000	=	Rp	300.000.000
Workman	=	12	x	120	x	Rp 125.000	=	Rp	180.000.000
Foeman	=	2	x	120	x	Rp 150.000	=	Rp	36.000.000
Overxeer	=	1	x	120	x	Rp 200.000	=	Rp	24.000.000
TOTAL							=	Rp	540.000.000

Total Cost by Adding Workers = (Total cost per day + Total Cost adding workers) = Rp 1.020.000.000

TABLE 3
Incremental Cost Trial and Error 1

Simbol	Activity	Normal			Crashing		
		Duration (hari)	Cost		Duration (hari)	Cost by Overtime	Cost by Adding Workers
A1	Excavate and Embankment Work	24	Rp	5.626.900.682,50	24	Rp 5.626.900.682,50	Rp 5.626.900.683
A2	Rip-Rap Embankment Work	24	Rp	102.296.396,02	24	Rp 102.296.396,02	Rp 102.296.396
A3	Drilling and Grouting Work	24	Rp	171.143.979,50	24	Rp 171.143.979,50	Rp 171.143.980
A4	Concrete Work	192	Rp	38.267.438.318,78	120	Rp 38.933.758.318,78	Rp 39.287.438.319
A5	Drainage Work	24	Rp	174.185.647,75	24	Rp 174.185.647,75	Rp 174.185.648
A6	Setting Work	24	Rp	471.605.715,48	24	Rp 471.605.715,48	Rp 471.605.715
A7	Bridge Work	24	Rp	482.198.632,31	24	Rp 482.198.632,31	Rp 482.198.632
A8	Others Work	48	Rp	1.297.999.704,46	48	Rp 1.297.999.704,46	Rp 1.297.999.704
TOTAL			Rp	46.593.769.076,80		Rp 47.260.089.076,80	Rp 47.613.769.076,80

TABLE 4
Incremental Cost Trial and Error 2

Simbol	Activity	Normal			Crashing		
		Duration (hari)	Cost		Duration (hari)	Cost by Overtime	Cost by Adding Workers
A1	Excavate and Embankment Work	24	Rp	5.626.900.682,50	24	Rp 5.626.900.682,50	Rp 5.626.900.683
A2	Rip-Rap Embankment Work	24	Rp	102.296.396,02	24	Rp 102.296.396,02	Rp 102.296.396
A3	Drilling and Grouting Work	24	Rp	171.143.979,50	24	Rp 171.143.979,50	Rp 171.143.980
A4	Concrete Work	192	Rp	38.267.438.318,78	144	Rp 38.946.638.318,78	Rp 39.395.438.319
A5	Drainage Work	24	Rp	174.185.647,75	24	Rp 174.185.647,75	Rp 174.185.648
A6	Setting Work	24	Rp	471.605.715,48	24	Rp 471.605.715,48	Rp 471.605.715
A7	Bridge Work	24	Rp	482.198.632,31	24	Rp 482.198.632,31	Rp 482.198.632
A8	Others Work	48	Rp	1.297.999.704,46	48	Rp 1.297.999.704,46	Rp 1.297.999.704
TOTAL			Rp	46.593.769.076,80		Rp 47.272.969.076,80	Rp 47.721.769.076,80

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TABLE 5
Incremental Cost Trial and Error 3

Simbol	Activity	Normal		Crashing		
		Duration (hari)	Cost	Duration (hari)	Cost by Overtime	Cost by Adding Workers
A1	Excavate and Embankment Work	24	Rp 5.626.900.682,50	24	Rp 5.626.900.682,50	Rp 5.626.900.683
A2	Rip-Rap Embankment Work	24	Rp 102.296.396,02	12	Rp 102.296.396,02	Rp 102.296.396
A3	Drilling and Grouting Work	24	Rp 171.143.979,50	24	Rp 171.143.979,50	Rp 171.143.980
A4	Concrete Work	192	Rp 38.267.438.318,78	120	Rp 38.284.058.318,78	Rp 38.295.338.319
A5	Drainage Work	24	Rp 174.185.647,75	24	Rp 174.185.647,75	Rp 174.185.648
A6	Setting Work	24	Rp 471.605.715,48	24	Rp 471.605.715,48	Rp 471.605.715
A7	Bridge Work	24	Rp 482.198.632,31	24	Rp 482.198.632,31	Rp 482.198.632
A8	Others Work	48	Rp 1.297.999.704,46	48	Rp 1.297.999.704,46	Rp 1.297.999.704
TOTAL			Rp 46.593.769.076,80		Rp 46.610.389.076,80	Rp 46.621.669.076,80

From Trial and Error 1, 2, and 3 obtained a graph of the relationship of critical time and critical costs as follows:

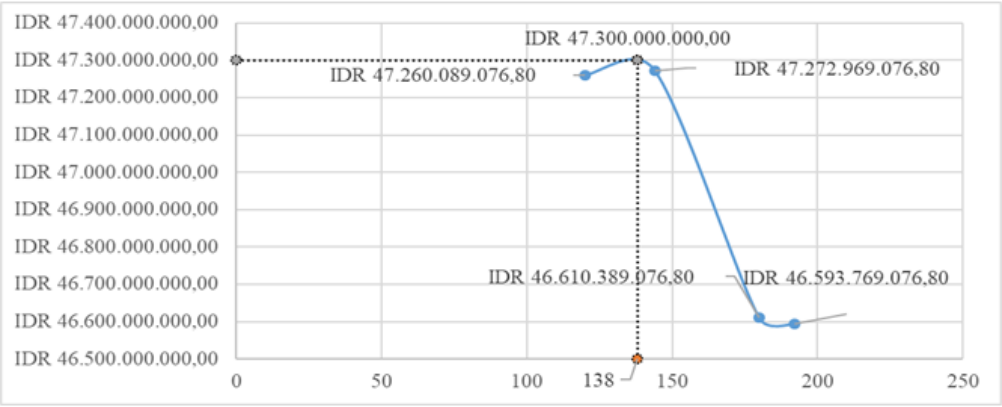

Figure 5: Graph Relationship of critical time and critical costs with additional work time (overtime) Trial and Error 1, Trial and Error 2, and Trial and Error 3

From this graph, can get the optimum value for cost and duration use by the overtime method. The value of cost is IDR 47,300,000,000,- with the optimum duration is 138.

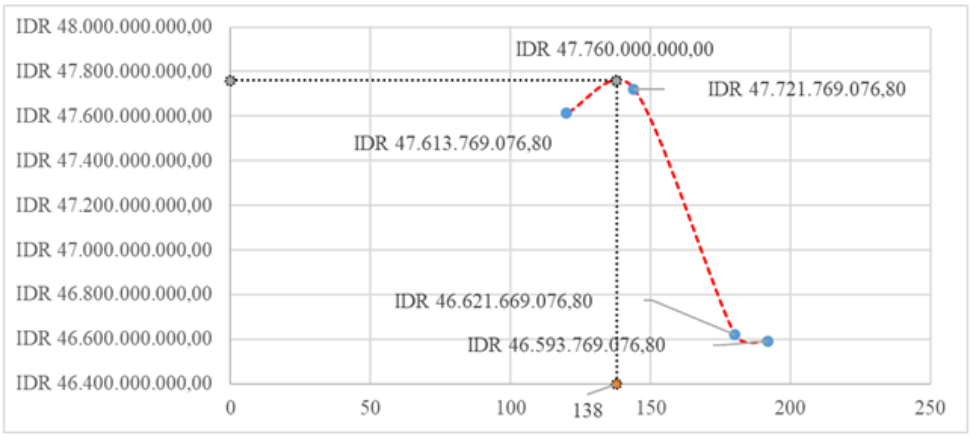

Figure 6: Graph Relationship of critical time and critical costs with the addition of labor Trial and Error 1, Trial and Error 2, and Trial and Error 3

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From this graph, can get the optimum value for cost and duration use by the Adding workers method. The value of cost is IDR 47,760,000,000,- with the optimum duration is 138.

IV. CONCLUSION

After rescheduling (rescheduling) and the creation of a network diagram using the CPM method, a number of trial and error trials are produced as follows:

a) Trial and Error 1
   Normal Cost : IDR 46,593,769,076.80
   Normal Duration : 9 months
   After creating a network diagram using the CPM method the results :
   With overtime method :
   IDR.47,260,089,076.80
   With the addition of labor :
   IDR.47,613,769,076.80.
   Critical Pathway : in A-D-H activities
   Critical Time : 6 months

b) Trial and Error 2
   Normal Cost : IDR 46,593,769,076.80
   Normal Time : 9 months
   After creating a network diagram using the CPM method the results :
   With overtime work :
   IDR.47,272,969,076.80
   With the addition of labor :
   IDR.47,721,769,076.80
   Critical Pathway : in A-D-H activities
   Critical Time : 7 months

c) Trial and Error 3
   Normal Cost : IDR 46,593,769,076.80
   Normal Time : 9 months
   After creating a network diagram using the CPM method and the crashing job is a rip-rap job, the results are:
   With overtime work :
   IDR.46,610,389,076.80
   With the addition of labor :
   IDR.46,621,669,076.80
   Critical Pathway : in A-C-H activities
   Critical Time : 8.5 months

Based on the results of research and graphic get the same optimum duration for this crashing, it is **138 days**. But, different optimum costs. By using the method of **adding labor the cost used is more that is IDR 47,760,000,000**,- and the **overtime work method required is IDR 47,300,000,000**,- Its mean that use overtime method more effective and get the optimum cost and duration than use additional labor method.

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