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EVALUATION OF FACTORS CAUSING DELAYS IN ROAD RECONSTRUCTION PROJECTS AND PLANNING COST AND TIME CONTROL (Case Study Of Reconstruction Project / Capacity Building Of Road Structures: Cabi-Bumi Rata R.074 Dak Regular Simpang Empat District, Banjar Regency)

Yoga Langgeng Yuana, Henry Wardhana

Civil Engineering Study Program, Faculty of Engineering, University of Lambung Mangkurat
Jl. A. Yani Km. 35,8 South Kalimantan, Indonesia
E-mail: yogalanggengyuana99@gmail.com

ABSTRACT

The implementation of the Reconstruction project/Capacity Building of Road Structures: Cabi-Bumi Rata R.074 DAK Regular Simpang Empat District, Banjar Regency in the process of its work has the potential to experience delays. As a result, there will be an increase in costs due to late fees so that time control is needed so that the project is not late with minimal costs. This study was conducted to determine the time of delay and the cause of delay in the project by conducting an interview so that project time control can be carried out. Furthermore, the results of the interview were analyzed with the Precedence Diagram Method (PDM) whether the late work passed the critical path. Once it is known that the work is late passing the critical path in the 8th week then calculates the residual volume and duration of the remainder then put into the PDM at week 8. From the duration of the remainder is known the duration of the delay and can calculate the cost of the fine. Adding overtime and work shifts was chosen as an alternative to completing delays because with 4-hour overtime the work is still late and continued by calculating daily productivity, productivity after a crash, duration of crashes and cost increase from the two alternatives, the minimum cost of each job was chosen to obtain a duration that matches the duration of the plan with minimal costs. The results of the research that has been carried out by the project have been delayed due to natural factors that cause the Matraman bridge to be cut off and result in mobilization, procurement of materials and equipment delayed in LPA and LPB work on critical lines. Based on the analysis using PDM in the 8th week, the project experienced a delay of 33 days so that the duration increased to 173 days from the 140-day plan duration with a fine of Rp 172,766,051. Efforts that can be made to overcome these delays are by combining adding overtime for 4 hours and adding work shifts. There is an increase in costs for each activity in line with the shortened duration of the delay. The total increase was IDR 121,137,087 and the total cost was IDR 5,356,471,979. With this analysis, the project can be completed on time with a duration of 140 days, the difference in the cost of fines with crashing is IDR 51,628,964 which can be used as a graph of the relationship between cost and time based on cost increase when accelerating.

Keywords: Project Delay, PDM, Cost Comparison, and Time.

1. INTRODUCTION

Construction project work must have the proper scheduling, planning and execution of work methods. In the process of work, problems are often encountered that cause delays that result in delays and fines.

Delays in construction projects are not only due to the fault of contractors or work implementers who do not follow existing contracts and procedures but are caused by other factors such as natural factors.

Projects that experience delays will harm all parties, contractors experience fines due to delays and owners cannot use the project as appropriate according to the specified time.

Therefore, it is necessary to improve the method of work and project scheduling to prevent or correct delays so that there is no excessive cost overrun.

2. LITERATURE REVIEW

2.1 Common

A construction project is a very complex and interrelated work, so that if one of the jobs experiences obstacles, it will result in other work.

According to George Robert Terry, a According to D.I. Cleland and W.R. King (1987), a construction project is a collection of various resources that are combined into one to complete a targeted job. Existing work can be in the form of repairs as well as new developments.

2.2 Project Delays

Late construction projects are characterized by an increase in the duration of their work, the volume does not match the volume of the plan or at the deadline of the implementation of the project has not been completed and results in fines from delays.

2.2.1 Factors causing delay

There are many factors that cause the project to be late but in general the delay factors are as follows:

1. Natural factors

2. Equipment factor
3. Labor factor
4. Material factors
5. Financial factors

2.2.2 Efforts to Prevent Delays

1. Increase working hours (overtime)
2. Add a workgroup at a different time (shift)
3. Add work tools
4. Adding workers
5. Choosing an effective method

2.3 Precedence diagram method (PDM)

PDM is scheduling that connects each dependency of a job that is square in shape with the previous job with arrows.

2.3.1 Stages in PDM scheduling

1. Determining work dependencies
2. Create a working network with the duration of the job
3. Perform back and forth calculations
4. Determining the critical trajectory

2.4 Method Crashing

Crash is a method to speed up the completion of work so that it is not late by emphasizing on critical work. The stages in Crashing are as follows:

1. Build a working network
2. Perform calculations of the duration of normal work
3. Perform calculations of the duration of late work
4. Calculating the fine as a result of the delay
5. Determining the acceleration method
6. Perform the calculation of the normal cost of each job
7. Conducting calculations of the acceleration of work

8. Calculating the cost slope of the work
9. Shorten work time based on lowest cost slope
10. Calculating the total cost of acceleration
11. Comparing fine fees and acceleration fees

3. RESEARCH METHODS

The research method carried out is related literature in order to find out the cause of the late project and be able to plan time control at minimal cost. The data needed in this study are:

1. Data primer

   This data is in the form of data from interviews with implementing contractors and direct reviews in the field or occupation of work in Simpang Empat District, Banjar Regency.

2. Secondary data

   This data is in the form of data obtained indirectly or from a job agency. The data is in the form of RAB, time schedule, weekly, and monthly reports.

4. RESULT AND DISCUSSION

4.1 Delay factors

Based on the results of the interview, it was found that the delay factor was in the form of natural factors that caused the Matraman bridge to be cut off which caused the LPA and LPB work in the 8th week to be disrupted because the mobilization of tools and materials could not be carried out.

Once known delay the next stage analyzes whether the delay occurred on a critical trajectory. If the delay occurs on a critical trajectory, it is necessary to accelerate.

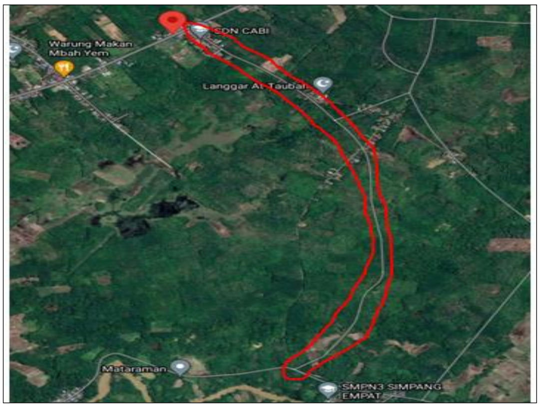


Figure 1. Project Location

4.2 Crashing jobs

4.2.1 Analyzing dependency logic

In scheduling using PDM, there are four dependencies, namely SS, FF, SF, and FF. the duration used in the dependency logic is the normal duration. Here is the logic of the dependence of activities in the project:

Table 4.1 List of Dependents of Activities

Type of Work	Activity Code	Previous Dependencies	Log. Dependency (days)
Mobilization	A1	-	FS (0)
Traffic Management and K3	A2	-	FS (0)
Excavations	B	A1	SS (14)
Heaps From Excavated Sources	C	B	FS (0)
Heap of Choice	D	C	FS (0)
Drainage	E	D	SS (14)
LPB	F	D	SS (7)
LPA	G	F	SS (14)
Masonry	H	F	SS (14)

Type of Work	Activity Code	Previous Dependencies	Log. Dependency (days)
Asphalt	I	G	SS (28)
Concrete fc' 15 Mpa	J	I	SS (14)
Road Markings	K	J	FS (0)
Demobilization	L	J	FS (0)

4.2.2 Create a PDM Network

Once it is known the dependency logic of each work the next stage is to create a PDM based on that duration.

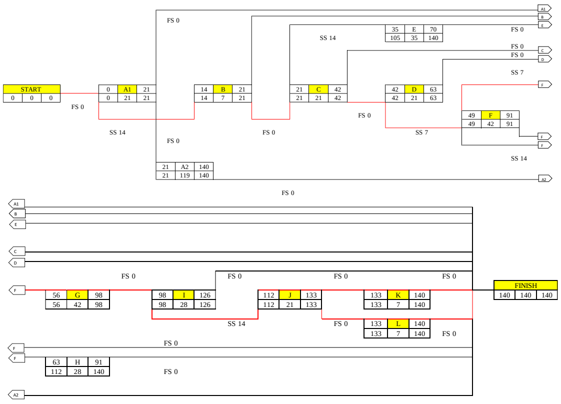


Figure 1. PDM network plans

Critical Path = A1-B-C-D-F-G-I-J-K
= A1-B-C-D-F-G-I-J-L
= A1-A2
Duration = 140 Days

4.2.3 Time Identification of Each Activity

From figure 1 above, it is known the start, finish, free float, total float, and critical activities. Float is the grace period of a non-critical activity of a job which can be in the following table:

Table 4.2 float jobs

Activity Code	Duration (days)	Forward Calculation		Countdown	
		IT	IF	LS	LF
A1	21	0	21	0	21
A2	119	21	140	21	140
B	7	14	21	14	21
C	21	21	42	21	42
D	21	42	63	42	63
E	35	56	91	105	140
F	42	49	91	49	91

Activity Code	Duration (days)	Forward Calculation		Countdown	
		IT	IF	LS	LF
G	42	63	105	63	105
H	28	63	91	112	140
I	28	91	119	91	119
J	21	105	126	105	126
K	7	126	133	126	133
L	7	133	140	133	140

4.2.4 Calculate the remaining volume and duration of the rest of the work

The remaining volume of work is the volume that has not been completed to the limit of completion. While the residual duration is the duration required to complete the residual work.

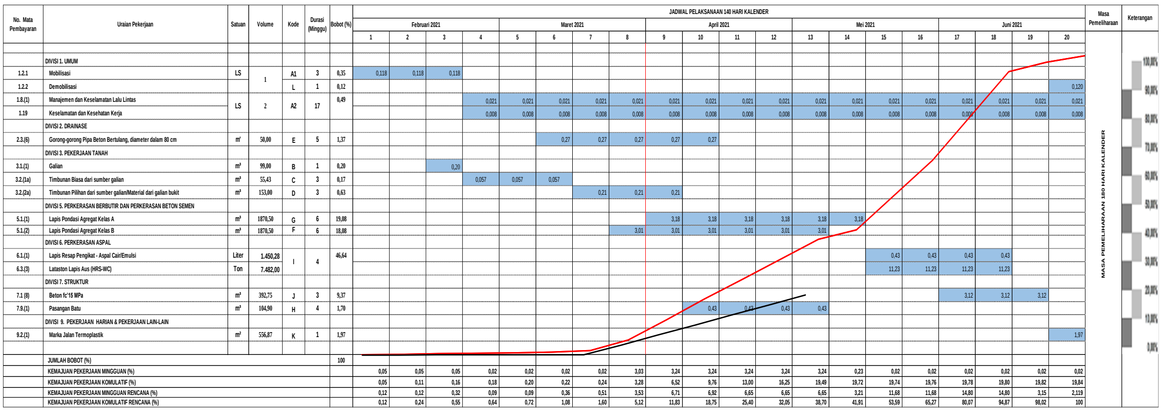


Figure 2. S curve

It was noticed that in the 8th week that the realization by 3.28% was below the plan by 5.12% and it can be concluded that the project was delayed.

An example of calculating the residual volume and duration of the remaining LPA work

Volume of remaining work = total volume – residual volume

= 1870,50 – 122,10

= 1748,40 m3

Residual duration $= \frac{\text{total}}{\text{residu}}$ x Durasi normal

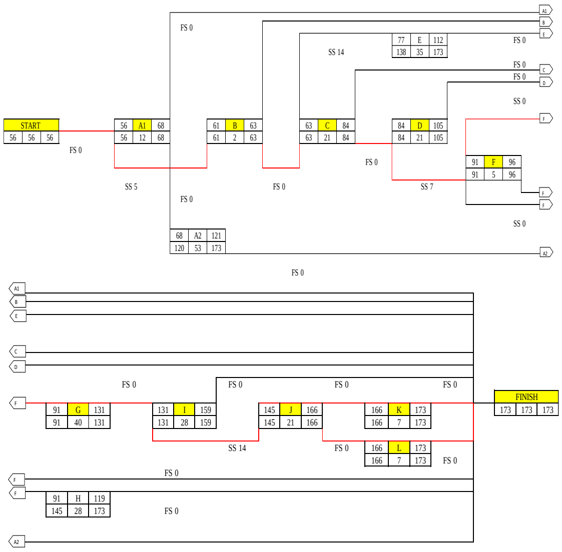
$= \frac{1870,50}{122,10}$ x 42 = 40 days

Table 4.3 Residual volumes and residual duration

Code	Duration (Days)	V. CCO	Real	Volume Time	Duration of Time
A1	21	0,75	0,34	0,41	12
L	7	0,25	0,00	0,25	7
A2	145	2	1	1	53
And	35	50,00	0,00	50,00	35
B	7	99,00	78,00	21,00	2
C	21	55,43	0,00	55,43	21
D	21	153,00	0,00	153,00	21
G	42	1870,50	122,10	1748,40	40
F	42	1870,50	1688,40	182,10	5
I	28	8932,28	0,00	8932,28	28
J	21	392,75	0,00	392,75	21
H	28	104,90	0,00	104,90	28
K	7	556,87	0,00	556,87	7

4.2.5 Network Tracking Schedule

The next stage is to enter the remaining duration of work into the PDM network starting at week 8 (day 56).



Critical Network = A1-B-C-D-F-G-I-J-K

= A1-B-C-D-F-G-I-J-L

Duration = 173 days

4.3 Late Fee

From the M-8 work network, it is known that the project experienced a delay of 33 days. Late fees can be calculated as follows:

The amount of the penalty fee = Contract value x (1/1000) x duration of delay

=Rp 5.235.334.891 x 1/1000 x 33 days

= IDR 172,766,051

Total cost = plan cost + fine cost

= IDR 5,235,334,891 + IDR 172,766,051

= IDR 5,408. 100,943

4.4 Crashing By Adding Overtime And Work Shifts

4.4.1 Calculate Daily Productivity

Daily productivity can be obtained by dividing the volume of a job by the duration of the work.

An example of calculation is the work of the LPA

Daily productivity $= \frac{\text{Volume}}{\text{Normal Duration}}$

$= \frac{1748,4}{40}$

$= 43,710\ m^3/\text{Day}$

4.4.2 Calculate Daily Productivity

An example of calculation is the work of the LPA

Hourly productivity $= \frac{\text{Daily Productivit}}{\text{Normal Working Hours.}}$

= 43,710: 7 Hours = 6.24 m3/Hour

4.4.3 Daily Productivity After a Crash (PHSC)

Daily Productivity After a Crash is the productivity obtained after a Crash. PHSC will be greater than daily productivity because it is coupled with overtime productivity and the addition of work shifts.

With the increase in overtime working hours from normal working hours, it will cause productivity to decrease, a decrease in productivity up to 25% of normal productivity.

As for daily productivity by adding work shifts, it does not decrease because with the change of workers but with the addition of work shifts can only work for 5 hours effective from 7 normal working hours in 1 day from 17:00-23:00 (including 1 hour of work rest).

It is known that the project experienced a relatively large delay of 33 days and with the addition of overtime 1,2 and 3 hours it is not possible to restore it to its original duration so the alternative used is to increase overtime for 4 hours.

An example of calculating LPA work by increasing working hours for 4 hours

- Example of calculating LPA work by adding 4 hours of work

PHSC = Daily productivity + (4 x Hourly productivity x 75%)

PHSC = 43,710 + (4 x 6,244 x 75%)

= 62,433 $m^3{}_{/day}$

- An example of calculating LPA work by adding a work shift

  PHSC = Daily productivity + (Daily productivity x (5/7))

  PHSC = 43,710 + (43,710 x (5/7))

  = 74,931 $m^3{}_{/day}$

4.4.4 Calculating Crash Duration

Crash duration is the duration of the work that can be accelerated so that the completion of the work will be faster than the duration of the delay.

- Example of Calculation of LPA work with the addition of working hours for 4 hours

  Crash Duration $= \frac{\text{Volume}}{\text{P.H.S.C}}$

  Crash Duration $= \frac{1748,40}{62,433} = 28 \text{ Hari}$

- An example of calculating LPA work by adding a work shift

  Crash Duration $= \frac{\text{Volume}}{\text{P.H.S.C}}$

  Crash Duration $= \frac{1748,40}{74,931} = 24 \text{ Hari}$

4.4.5 Accelerated Costs of Adding Working Hours and Shifts

To find out the comparison of additional costs for the acceleration process, first calculate the normal cost with the acceleration cost by adding working hours for 4 hours and adding work shifts.

- Example of calculation by increasing working hours for 4 hours on LPA work

  Normal cost = Rp 908.237.829

  SNI coefficient = The price of workers' wages for overtime work according to the Decree of the Minister of Manpower Kep.102/VI/2004 article 11

  Coefficient of the first 1 hour of overtime = 1,5

Coefficient of 2 hours of overtime

= 1,5 + 2

Coefficient of 3 hours of overtime

= 1,5 + 2 + 2

Coefficient of 4 hours of overtime

= 1,5 + 2 + 2 + 2

Crash cost = normal cost + (SNI coefficient x hourly wage cost x Crash duration)

= Idr 908,237,829 + (7.5 x ((Rp 19,300 x 16 drivers) + (Rp 22,200 x 2 heavy equipment operators) + (Rp 22,200 x 1 foreman)) x 28)

= IDR 987,071,829

Normal Duration = 40 days

Crash duration = 28 days

Cost Slope $= \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Duration} - \text{Crash Duration}}$

Cost Slope $= \frac{\text{Rp } 987{,}071{,}829 - \text{Rp } 908{,}237{,}829}{40 - 28}$

= IDR,569,500.00

- Example of calculation by adding a work shift to the LPA work

First Shift = Number of Workers x Salary Per day

Driver = 16 Driver x Salary per day

= 16 x IDR 135,100

= IDR 2,161,600.00

Operator = 2 Operator x Salary per day

= 2 x IDR 155,400

= IDR 310,800.00

Foreman = 1 Foreman x Salary per day

= 1 x IDR 155,400

= IDR 155,400

Second Shift fee increase = Number of Workers x (First working hours/ Second shift working hours) x Workers' salary per day

Second shift = Number of Workers x (7/5) x Salary per day

Driver = 16 Driver x (7/5) x Salary per day

= 16 x (7/5) x IDR 135,100

= IDR 3,026,240.00

Operator = 2 Operator x (7/5) x Salary per day

= 2 x (7/5) x RP 155,400.00

= IDR 435,120.00

Foreman = 1 Foreman x (7/5) x Salary per day

= 1 x (7/5) x Rp 155,400

= IDR 217,560.00

Total increase in the cost of the second shift = Second shift driver salary + Second shift Operator salary + Second shift foreman salary

= IDR 3,026,240.00 + IDR 435,120.00 + IDR 217,560.00

= IDR 3,678,920.00

Crash cost = normal cost + (total shift cost x Crash duration)

= Rp 908,237,829 + (Rp 3.678.920 x 24 days) = Rp 996,531,909

Normal Duration= 40 days

Crash duration= 24 days

Cost Slope $= \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Duration} - \text{Crash Duration}}$

Cost Slope $= \frac{\text{Rp } 996{,}531{,}909 \ - \text{Rp } 908{,}237{,}829}{40 - 20}$ = IDR 5,518,380

For the overall cost slope with the addition of overtime can be seen in table 4.4 and for the addition of work shifts can be seen in table 4.5.

Table 4.4 Productivity after crashes and Overtime Costs

Code	Time Duration (Days)	Flight. Sisa	Prod. Daily	Prod. Every Hour	Productivity After Overtime Crashing (75%)	Overtime crashes	Normal Cost	Overtime Crash Fee	R (Overtime)
A1	12	0,42	0,04	0,01	0,05	9	Rp16.781.250	Rp23.463.750	Rp2.227.500
L	7	0,25	0,04	0,01	0,05	5	Rp5.593.750	Rp9.306.250	Rp1.856.250
C	21	55,43	2,64	0,38	3,77	15	Rp8.310.616	Rp31.935.616	Rp3.937.500
D	21	153,00	7,29	1,04	10,41	15	Rp29.937.847	Rp53.562.847	Rp3.937.500
G	40	1748,40	43,71	6,24	62,44	28	Rp908.237.829	Rp987.071.829	Rp6.569.500
F	5	182,10	36,42	5,20	52,03	4	Rp860.276.993	Rp871.538.993	Rp11.262.000
I	28	8932,28	319,01	45,57	455,73	20	Rp2.219.534.968	Rp2.296.709.968	Rp9.646.875
J	21	392,75	18,70	2,67	26,72	15	Rp446.050.853	Rp495.123.353	Rp8.178.750
K	7	556,87	79,55	11,36	113,65	5	Rp93.693.087	Rp101.841.837	Rp4.074.375

Table 4.5 Productivity after crashes and Overtime Costs

Code	Time Duration (Days)	Theft. Remnant	Prod. Harian	Prod Shift to 2	Productivity After Crashing (Number of shifts)	Crash Duration shift work	Normal Cost	Crash Shift Charges	R (Shift)
A1	12	0,42	0,04	0,03	0,06	7	IDR 16,781,250	IDR 23,410,678	Rp1.276.253
L	7	0,25	0,04	0,03	0,06	5	IDR 5,593,750	IDR 10,464,350	Rp2.435.300
C	21	55,43	2,64	1,89	4,52	13	IDR 8,310,616	IDR 33,892,536	Rp3.197.740
D	21	153	7,29	5,20	12,49	13	IDR 29,937,847	IDR 55,519,767	Rp3.197.740
G	40	1748,4	43,71	31,22	74,93	24	IDR 908,237,829	IDR 996,531,909	Rp5.518.380
F	5	182,1	36,42	26,01	62,43	3	IDR 860,276,993	IDR 872,592,653	Rp6.157.830
I	28	8932,28	319,01	227,86	546,87	17	IDR 2,219,534,968	IDR 2,306,700,088	Rp7.924.102
J	21	392,75	18,70	13,36	32,06	13	IDR 446,050,853	IDR 494,997,933	Rp6.118.385
K	7	556,87	79,55	56,82	136,38	5	IDR 93,693,087	IDR 103,439,187	Rp4.873.050

4.5 Cost Ranking

After the calculation of Crashing using the addition of overtime working hours and the addition of shifts, the next step is to rank the costs

Table 4.6 Cost Slope Costs of Adding Overtime and Shift Work

Work	R (Overtime)	A (Sift)	R (Min)
A1	IDR 2,227,500	IDR 1,276,253	IDR 1,276,253
L	IDR 1,856,250	IDR 2,435,300	IDR 1,856,250
B	IDR 931,500	Rp -	IDR 931,500
C	IDR 3,937,500	IDR 3,197,740	IDR 3,197,740
D	IDR 3,937,500	IDR 3,197,740	IDR 3,197,740
G	IDR 6,569,500	IDR 5,518,380	IDR 5,518,380
F	IDR 11,262,000	IDR 6,157,830	IDR 6,157,830
I	IDR 9,646,875	IDR 7,924,102	IDR 7,924,102
J	IDR 8,178,750	IDR 6,118,385	IDR 6,118,385
K	IDR 4,074,375	IDR 4,873,050	IDR 4,074,375

From table 4.6, it is known that the R of each job is used and the smallest R of each job is used. So that there is a combination of adding overtime work hours and adding work shifts to be used at the next stage, namely calculating the duration and increasing costs using the crash duration that has been obtained previously.

Selection of R based on the smallest R of each activity in order to obtain the most minimal cost.

From table 4.6 it is known that there are 6 activities with the smallest R. These activities combine between increasing overtime and shift work hours. Its activities include excavation, mobilization, demobilization, ordinary heaps from the source of excavations, heaps of choice from the source of excavations, and activities of the upper foundation layers. Combining with two Crash methods with the aim of obtaining the most minimal costs.

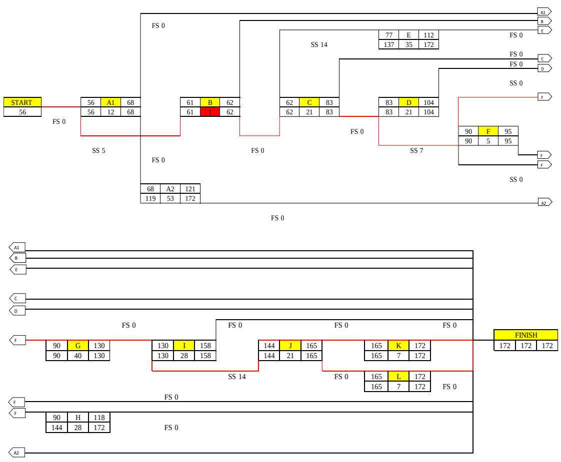
Table 4.7 Calculation of Crash Duration and Additional Costs

Keg	DS	DC	R	DS-DC	Crash	Cumulative Crashes	Additional Fees	Cumulative Costs	Duration of Project Time	Information
B	2	1	IDR 931,500	1	1	1	IDR 931,500	IDR 5,236,266,391	172	> 140 Days
A1	12	7	IDR 1,276,253	5	5	6	IDR 6,381,267	IDR 5,242,647,659	167	> 140 Days
L	7	5	IDR 1,856,250	2	2	8	IDR 3,712,500	IDR 5,246,360,159	165	> 140 Days
C	21	15	IDR 3,197,740	6	6	14	IDR 19,186,440	IDR 5,265,546,599	159	> 140 Days
D	21	15	IDR 3,197,740	6	6	20	IDR 19,186,440	IDR 5,284,733,039	153	> 140 Days
G	40	24	IDR 5,518,380	13	13	33	IDR 71,738,940	IDR 5,364,620,729	140	Ok

From table 4.7 above, it is known that there were 6 Crashes to get a duration that matched the duration of the 140-day plan. There are two combinations of crashing methods, namely by increasing overtime and increasing work shifts. The selection of the method is based on the selection of the smallest R on the work performed by adding working hours and increasing the work shift.

4.6 Crashing Jobs

1. Crashing excavation work



Critical Path

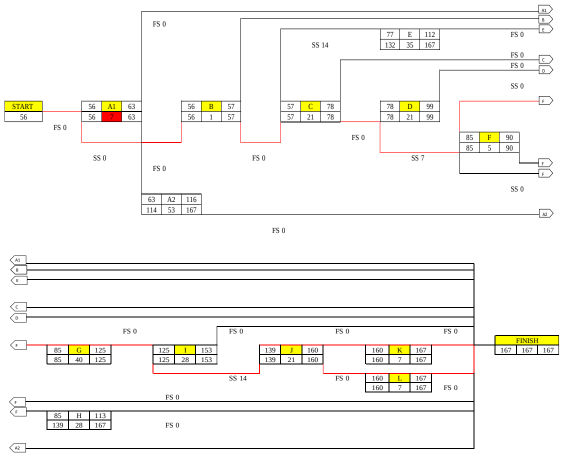
A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 931,500 + the plan cost is IDR 5,235,334891 = IDR 5,236,266,391

Duration 172 days

2. Crashing Mobilization Work



Critical Path

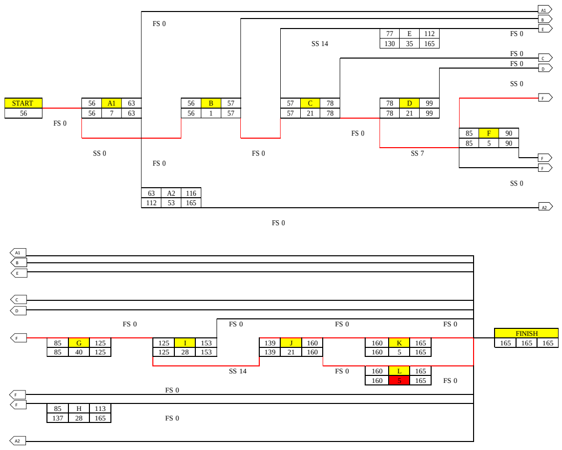
A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 6,381,267 + IDR 5,236,266,391 = IDR 5,242,647,659

Duration 167 days

3. Crashing On Demobilization Work



Critical Path

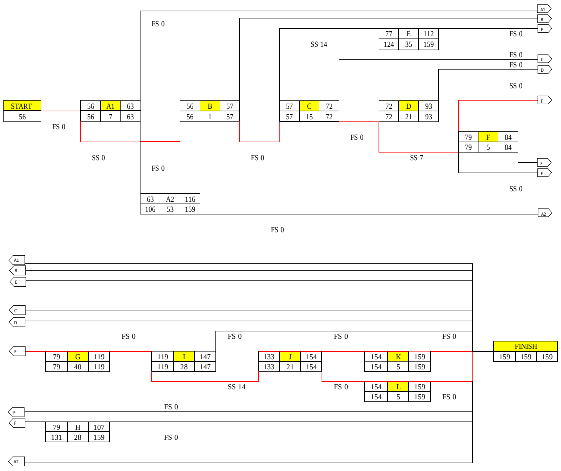
A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 3,712,500 + IDR 5,242,647,659 = IDR 5,246,360,159

Duration 165 days.

4. Crashing On Regular Heap Work



Critical Path

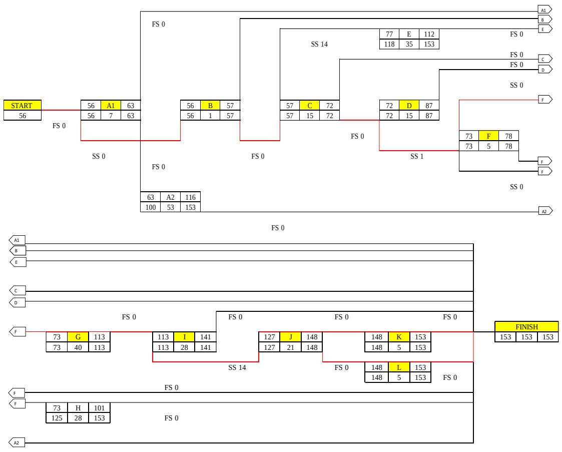
A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 19,186,440 + IDR 5,246,360,159 = IDR 5,265,546,599

Duration 159 days

5. Crashing On Heap Jobs of Choice



Critical Path

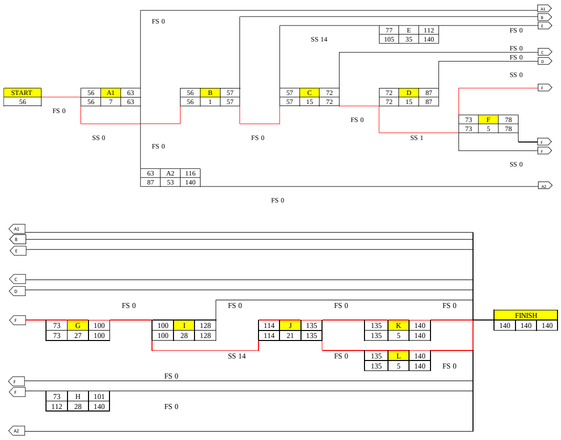
A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 19,186,440 + IDR 5,265,546,599 = IDR 5,284,733,039

Duration 153 days

6. Crashing On LPA Jobs



Critical Path

A1-B-C-D-F-G-I-J-K

A1-B-C-D-F-G-I-J-L

The additional cost required for the Crash is IDR 71,738,940 + IDR 5,284,733,039 = IDR 5,356,471,979

Duration 140 days

The costs on the addition of working hours for 4 hours and the addition of work shifts are as follows:

Plan duration = 140 days

Normal fee = Rp 5,235,334,891

Duration of delay = 173 days

Total cost of fine = Rp 5,408,100,943

Late fee = Rp 172,766,051

Crash realization duration = 140 days

Crash fee = Rp 121,137,087

Total Crash cost = Rp 5,356,471,979

The difference between late fees and crashes = Late fee – Crash fee

= IDR 5,408,100,943 – IDR 5,356,471,979

= IDR 51,628,964

4.7 Cost and Time Relationship Graph

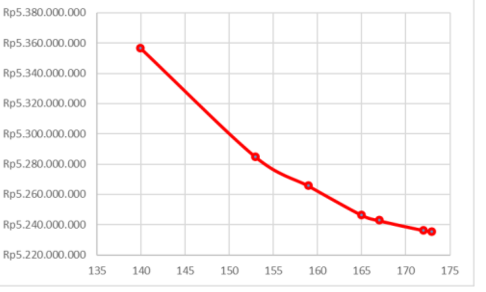


Figure 3. Graph of cost and time relationships

5.CONCLUSIONS

1. Construction projects experience delays due to several factors, the main factor being environmental factors. Due to the broken bridge, the mobilization of heavy equipment and construction materials to the site was disrupted.
2. The project experienced a delay of 33 days from the original schedule of 140 days to 173 days.
3. Based on these conditions, the alternative acceleration chosen in an effort to shorten the duration is to apply additional working hours and working shifts in week 8.
4. The additional cost required to speed up the completion of work for 33 days by increasing the number of working hours and working shifts is IDR 121,137,087 from the realization duration of 173 days to 140 according to the plan duration and the total cost of IDR 5,356,471,979
5. The difference in fees between late fees and Crash fees is IDR 51,628,964. So, the acceleration by adding overtime to work shifts is cheaper than paying fines due to delays.
6. From the calculation results, a graph was obtained that experienced an increase in costs along with the shortening of the project duration.

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