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COST ANALYSIS WITH CRASH PROGRAM OF KEROBOKAN PARKING LOT BUILDING BALI

Dwi Cahyani Putri*, Budi Witjaksana[2], Hanie Teki Tjendani[3]
[1,2,3]Civil Engineering Faculty of Technic, 17 Agustus 1945 Universitas, Indonesia

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Corresponding author*:
dwicahyaniptr45@gmail.com

No. Contact:
082211069485

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Abstract: Kerobokan Bali Parking Building is one of the buildings that uses steel material as the main structure. The building which has a height of 13.97 meters, a width of 32.8 meters, and a length of 16.18 meters has a construction plan duration of 248 calendar days starting from July 2023. Known critical trajectory activities will be carried out a crashing program analysis with the aim of accelerating time by using one method, namely overtime work with a duration of 4 hours. Based on the analysis that has been carried out with the help of the Microsoft Project 2019 application, there are 16 lists of activities included in the critical trajectory. In writing this thesis, it will be mentioned in the form of a line code in Microsoft Project 2019, namely 569-573-579-580-581-606-585-586-590-591-595-596-600-601-602-612. In addition to knowing the list of critical path activities, this thesis also accelerates the duration with an additional 4 hours of overtime and calculates the total cost of the acceleration. After acceleration, it is known that the duration decrease is 61 days with a normal duration of 248 days to 187 days and shows a time efficiency of 0.245%. The total initial cost with normal duration is Rp 8,822,280,000.00 while if the project is accelerated, the project cost becomes Rp 8,901,216,104.5 by showing an additional cost of Rp 78,936,104.47.

Keywords: Critical Path Method, Crashing Program, Overtime Work, Time Acceleration

INTRODUCTION

Parking building is a building specifically built for parking vehicles, thus the use of land, especially in the downtown area can be done efficiently. Parking buildings can be combined with activity centers, where the basement floor and several floors above are used for parking and then above them are placed activity center buildings such as shops, offices and other activity centers.

Unlike the construction of the Bali parking building, this Bali parking building was built specifically as a parking lot with 5 floors and a roof. This parking building is a parking facility for office staff, consumers and especially the owner of the Global Xtreme office. The distance between the Global Xtreme office to the parking building is about 250 meters. But on the back land of the Global Xtreme office there is vacant land and can be used as a connecting road, because the parking building is crushed by the Indomaret building in front of it, it becomes a problem during the construction process, because of narrow access and fear if material mobilization will damage Indomaret facilities.

The Bali parking building was built using steel materials, has a length of 16.18 and a width of 32.8 meters with a total building height of 13.97 meters. The planned duration of the construction of this parking building is 248 calendar days starting from July 23, 2023 and the project completion date is in June 2024, but in week 10 the project has been delayed. The Budget Plan Cost (RAB) for this Bali Parking Building project is IDR 8,822,280,000.00. The delay in the construction of this project has shown 68 days since early March. Delays are caused by flooding on the basement floor due to river water entering the project site. The excavation work is arguably quite deep and causes river water to enter, because the river water level is at elevation -2.85 meters, while the basement floor is at elevation -4.00 meters which makes other work hampered.

One of the efforts to overcome delays is to accelerate project completion by using the crashing method. The crashing method is usually done to catch up with achievements that were left behind at previous times due to changes or deviations. However, the crashing method can also be applied to a scheduling because it is

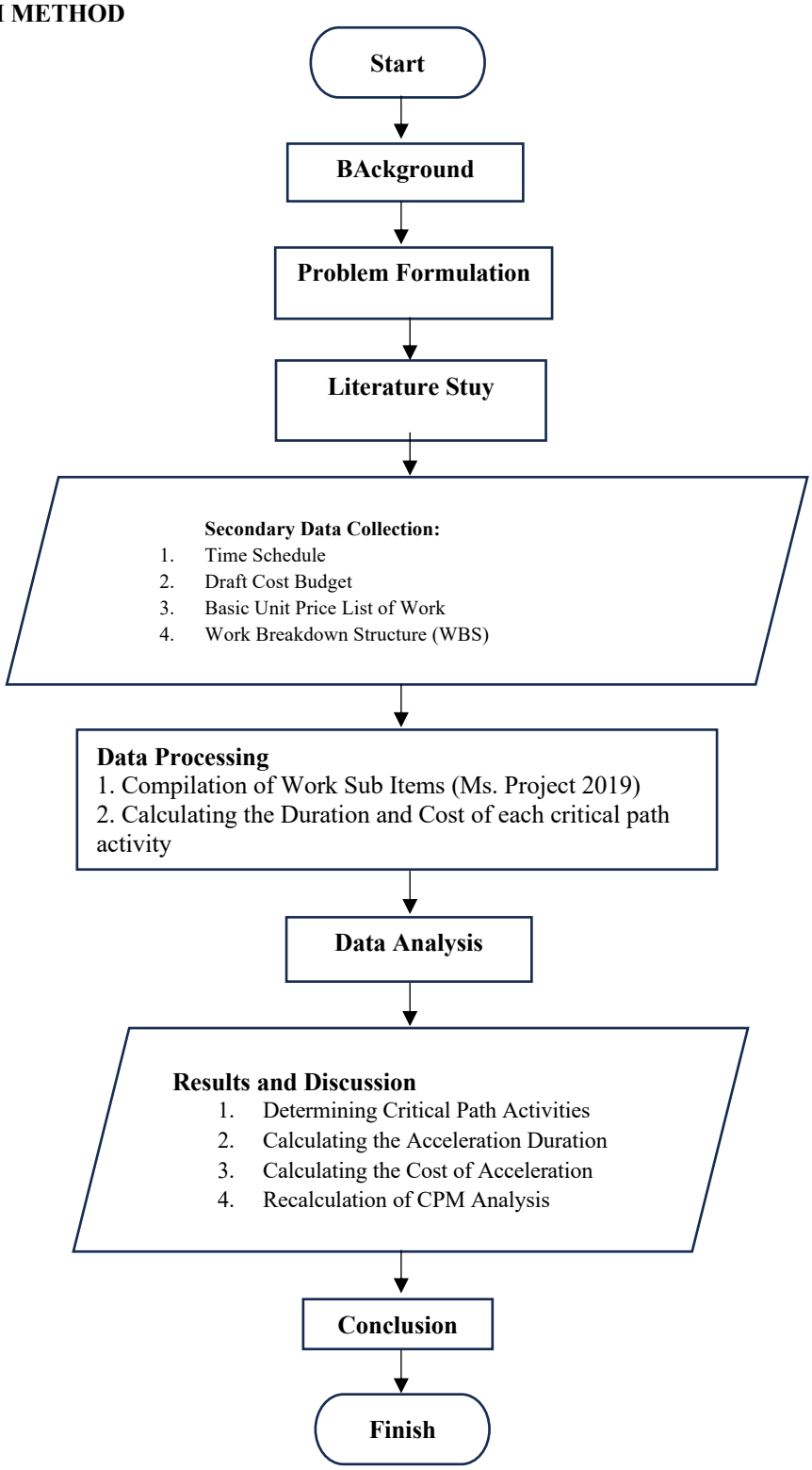
desired that the completion time of a project is faster than planned (Akhir, 2019). Controlling the implementation of project development by evaluating completion projections requires making the right decisions, determining goals in achieving standards, establishing a good management management system and immediately. This is so that deviations can be resolved and the project is completed on time without exceeding the predetermined budget. Thus this can be well received by consumers. To analyze the acceleration of duration, the initial stage that needs to be done is to find critical path activities using Microsoft Project 2019. Microsoft Project serves to assist project managers in developing plans, assigning resources to tasks, tracking project progress, managing budgets and analyzing workloads, assisting in planning, implementing and controlling the schedule and cost of a project in detail within the scope of activity by activity and recording and monitoring the use of human resources and equipment and packaged in accurate reports.

Based on the description above, in time management problems, it is necessary to accelerate the time to achieve progress according to the target. So this research will raise the title "Cost Analysis with Crash Program for Kerobokan Bali Parking Building" with the hope that after knowing the critical trajectory in the construction of the Bali parking building project, then also in this study will identify various critical trajectory activities in the project that have great potential in determining whether or not delays occur when the project takes place.

Tabel 1. Previous research

No	Peneliti Tahun	Judul Penelitian	Metode Penelitian	Hasil Penelitian
1	2	3	4	5
22.	(Akhir, 2019)	Analisis *Crash* Program Menggunakan *Microsoft Project* Pada Peningkatan Jalan SP. Lago-Sorek-I Kabupaten Pelalawan	*Crash Program*	The direct cost of the project has increased from Rp8,337,708,810.24 in 153 days to Rp8,350,722,726.78 in 133 days (0.15% increase).
16.	(Syaputra, 2019)	Analisa Penjadwalan Pelaksanaan Pekerjaan Proyek Dengan Metode CPM dan PDM Pada Peningkatan Jalan Sei Pakning (KM 130)-Teluk Masjid - Simpang Pusako Kabupaten Siak	*Critical Path Method & Precedence Diagramming Method*	The number of activities on the critical path if calculated using the CPM method is 14 activities with the total duration obtained is 183 days while the PDM method has four constraints, namely SS, FF, FS and SF.
3.	(Husna et al., 2022)	Implementasi CPM dan PERT dalam Memprediksi Durasi Serta Biaya Pembangunan Musala Al-Ikhlas	*Critical Path Method* & *Program Evaluation And Review Technique*	The shorter construction duration results in reduced labor costs.

RESEARCH METHOD



Gambar 1. Research Flowchart

Data Collection

Here are the steps to analyze *Crash* Program:

1. Data analysis uses the CPM method
2. Data analysis using *Crash* Program (Overtime)

a. Acceleration duration analysis
- Daily Productivity
  Daily productivity $= \frac{volume}{normal\ duration}$ ..... (2.1)
- Hourly productivity
  Hourly productivity $= \frac{Daily\ productivity}{Working\ hours\ per\ day}$..... (2.2)
- Overtime productivity
  Overtime Productivity = a x b x prod. tiap jam..... (2.3)
  Where :
  a = Length of additional working hours
  b = Coefficient of decrease in productivity of additional working hours
- Productivity after crashing
  Prod.after *crash* = Prod. daily + Prod. Overtime ……..... (2.4)
- *Crash duration*
  Crash duration $= \frac{Volume}{Productivity\ after\ crashing}$ ……..... (2.5)
- *Duration Variance*
  Duration Variance = Normal duration – Acceleration duration…….....(2.6)
- Total overtime hours
  Total overtime hours = Overtime hours x Acceleration duration..... (2.7)

b. Acceleration cost analysis
- Normal labor costs per day
  mn/day = Prod. daily x Unit Price Work Wages..... (2.8)
- Normal hourly labor costs
  Bn/hour = Prod. per hour x Work Wage Unit Price..... (2.9)
- Worker overtime costs
  First Overtime = 1.5 x wages in one hour..... (2.10)
  Next Overtime = 2 x wages in one hour..... (2.11)
- *Crash cost* workers per day
  Crash Cost = normal daily cost x *crash duration*..... (2.12)
- *Cost slope*
  Cost slope $= \frac{Crash\ cost - Normal\ Cost}{Normal\ Duration - Crash\ Duration}$..... (2.13)
- *Cost slope* acceleration
  Cost slope acceleration = *cost slope* x durasi crashing..... (2.14)
- *Cost Variance*
  Cost Variance = Acceleration costs – Normal costs..... (2.15)
- Direct cost
  Direct Costs = Previous cumulative costs – *CV*..... (2.16)
- Time efficiency
  And $= \left(\frac{project\ duration - cumulative\ duration}{project\ duration}\right) x100\%$ ..... (2.17)
- Cost Efficiency
  Ec $= \left(\frac{Project\ total\ cost - Cumulative\ total\ cost}{Total\ project\ costs}\right) x100\%$..... (2.18)

RESULT AND DISCUSSION

General Project Data

The project data that will be used as a reference in writing this research is as follows:

Tabel 2. Data Proyek

Project Name	: Kerobokan Bali Parking Lot Construction Project
Project Address	: Jl. Raya Kerobokan No.388X, Kerobokan Kelod, Kec.Kuta Utara, Kab. Badung Bali.
Structure Frame Material	: Steel Structure

Width	: 32.8 meters
Length	: 16.18 meters
Building Height	: 13.97 meters
Budget Before VAT	: IDR 7,948,000,000.00.
Budget with 11% VAT	: IDR 8,822,280,000.00.
Method used	: Crashing Program

Critical Path Method (CPM) Analysis

Critical Path Activities

Critical path activities are activities carried out over a long period of time without a break. From the entire list of project activities, the activities that will be crashed are only a list of activities contained in the critical path because later the time acceleration calculation will be carried out for activities included in the critical path. Critical trajectories can be obtained using the Microsoft Project 2019 program.

CRITICAL TASKS

CRITICAL TASKS

■ Status: Complete ■ Status: Late
■ Status: Future Task

A task is critical if there is no room in the schedule for it to slip.

Learn more about managing your project's critical path.

Name	Start	Finish	% Complete	Remaining Work
Plafon Gibsum Board, t: 9 mm + Rangka Hollow Galvalume	Tue 21/05/24	Tue 28/05/24	0%	0 hrs
Keramik Lantai UnPolisd, uk. 20 x 20 cm	Tue 21/05/24	Thu 30/05/24	0%	0 hrs
Pengecatan Baru Dinding Luar Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Dalam Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Plafon Dalam Mowilwx Putih	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Luar Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Dalam Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Luar Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Dalam Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Luar Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Dalam Mowilex	Thu 30/05/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Luar Mowilex	Thu 06/06/24	Fri 21/06/24	0%	0 hrs
Pengecatan Baru Dinding Dalam Mowilex	Thu 06/06/24	Fri 21/06/24	0%	0 hrs
Pengecatan Waterprofing Dgn Serat Membran	Thu 06/06/24	Fri 21/06/24	0%	0 hrs
Kusen / Pintu Alm + Kaca, P-1 (uk.80x226 cm)	Thu 23/05/24	Thu 06/06/24	0%	0 hrs
Kusen / Pintu / Jendela Alm + Kaca, PJ-2 (uk.228x226 cm)	Thu 23/05/24	Thu 06/06/24	0%	0 hrs

Figure 2. Critical Tasks Activity List
Source: Microsoft Project Analysis Data, 2024

Program Crashing Analysis

a.Accelerated Duration Analysis

Daily Productivity and Hourly Productivity

The calculation results of daily productivity and hourly productivity can be seen in table 4.2 as follows:

Table 3. Daily and Hourly Productivity Calculation Results

Work Line Code	dn	Sat	Volume	Prod. (/Days)	Prod. (/Hours)
569	6	m2	45,36	7,56	1,08
573	8	m2	2,45	0,31	0,04
579	18	m2	136,25	7,57	1,08
580	18	m2	479,35	26,63	3,80
581	18	m2	47,69	2,65	0,38
606	12	Set	1,00	0,08	0,01
585	18	m2	149,73	8,32	1,19
586	18	m2	378,79	21,04	3,01
590	18	m2	165,29	9,18	1,31
591	18	m2	382,72	21,26	3,04
595	18	m2	165,29	9,18	1,31
596	18	m2	426,17	23,68	3,38
600	12	m2	360,26	30,02	4,29
601	12	m2	231,21	19,27	2,75
602	**12**	**m2**	**504,00**	**42,00**	**6,00**

612	12	Set	2,00	0,17	0,02

Table 4.2 above is the result of the calculation of daily productivity and hourly productivity of each critical path activity.

- Overtime Productivity

The results of overtime productivity calculations can be seen in table 4.3 as follows:

Table 4. Overtime Productivity Calculation Results

ob Line Code	Overtime Productivity (per hour)			
	1 hour	**2 hours**	**3 hours**	**4 hours**
569	0,97	1,84	2,59	3,17
573	0,04	0,07	0,11	0,13
579	0,97	1,84	2,60	3,18
580	3,42	6,47	9,13	11,18
581	0,34	0,64	0,91	1,11
606	0,01	0,02	0,03	0,04
585	1,07	2,02	2,85	3,49
586	2,71	5,11	7,22	8,84
590	1,18	2,23	3,15	3,86
591	2,73	5,16	7,29	8,93
595	1,18	2,23	3,15	3,86
596	3,04	5,75	8,12	9,94
600	3,86	7,29	10,29	12,61
601	2,48	4,68	6,61	8,09
602	**5,40**	**10,20**	**14,40**	**17,64**
612	0,02	0,04	0,06	0,07

Source: Analysis Result Data *Microsoft Excel*, 2024

In Table 4.above are the results of calculating overtime productivity with varying durations of 1 hour, 2 hours, 3 hours and 4 hours per day.

- Productivity After *Crashing*

Productivity calculation results after *crashing* can be seen in table 4.4 as follows:

Table 5. Sesusah Productivity Calculation Results *Crashing*

Job Line Code	Prod. After *Crashing*			
	1 hour	**2 hours**	**3 hours**	**4 hours**
569	8,53	9,40	10,15	10,73
573	0,35	0,38	0,41	0,43
579	8,54	9,41	10,16	10,75
580	30,05	33,10	35,76	37,82
581	2,99	3,29	3,56	3,76
606	0,09	0,10	0,11	0,12
585	9,39	10,34	11,17	11,81
586	23,75	26,15	28,26	29,88
590	10,36	11,41	12,33	13,04
591	24,00	26,43	28,55	30,19
595	10,36	11,41	12,33	13,04
596	26,72	29,43	31,79	33,62
600	33,88	37,31	40,31	42,63
601	21,74	23,95	25,87	27,36
602	**47,40**	**52,20**	**56,40**	**59,64**
612	0,19	0,21	0,22	0,24

Source: Analysis Result Data *Microsoft Excel*, 2024

In table 5. are the results of the productivity calculation after *crashing* with varying durations of 1 hour, 2 hours, 3 hours and 4 hours for each critical path activity. The longer the overtime hours, the more productivity will be generated per day. In work with line code 602, namely waterprofing painting work with membrane fiber, it can be seen that if 1 hour of overtime is done it produces 47.40 m2/day,

if 2 hours of overtime is done it produces 52.20 m2/day, if 3 hours of overtime is done it produces 56.40 m2/day and if 4 hours of overtime is done it produces 59.64 m2/day.

- *Crashing Duration*

The calculation results *crashing duration* can be seen in table 4.5 as follows:

Table 6. The calculation results *Crash Duration*

Job Line Code	***Crashing Duration* (Day)**			
	1 hour	**2 hours**	**3 hours**	**4 hours**
569	5	5	4	4
573	7	6	6	6
579	16	14	13	13
580	16	14	13	13
581	16	14	13	13
606	11	10	9	8
585	16	14	13	13
586	16	14	13	13
590	16	14	13	13
591	16	14	13	13
595	16	14	13	13
596	16	14	13	13
600	11	10	9	8
601	11	10	9	8
602	**11**	**10**	**9**	**8**
612	11	10	9	8

Source: Analysis Result Data *Microsoft Excel*, 2024

In Table 6. are the calculation results for each *crash duration*. The longer the overtime hours, the shorter they will be *crash duration*. Line code 602 shows that if 1 hour of overtime is carried out, the required duration is only 11 days, if 2 hours of overtime is carried out, the required duration is only 10 days, if 3 hours of overtime is carried out, the required duration is only 9 days, whereas if 4 hours of overtime is carried out, the duration is only 9 days. it takes only 8 days.

- Duration Variance

The results of the variance duration calculation can be seen in table 4.6 as follows:

Table 7. The calculation results *Duration Variance*

Job Line Code	***Duration Variance***			
	1 hour	**2 hours**	**3 hours**	**4 hours**
569	1	1	2	2
573	1	2	2	2
579	2	4	5	5
580	2	4	5	5
581	2	4	5	5
606	1	2	3	4
585	2	4	5	5
586	2	4	5	5
590	2	4	5	5
591	2	4	5	5
595	2	4	5	5
596	2	4	5	5
600	1	2	3	4
601	1	2	3	4
602	1	2	3	4
612	1	2	3	4

Source: Analysis Result Data *Microsoft Excel*, 2024

In Table 7. are the calculation results of each duration variation for each critical path activity. Line code 602 shows that if 1 hour of overtime is carried out, the difference in duration is between the normal duration and the duration *crashing* namely 1 day, if two hours of overtime is done the difference is 2 days, if 3 hours of overtime is done the difference is 3 days and if 4 hours of overtime is done it shows a difference of 4 days from the normal duration.

- Total Overtime Hours

The results of calculating total overtime hours can be seen in table 4.7 as follows:

Table 8. Total Overtime Hours Calculation Results

Job Line Code	*Crashing Duration* (Day)				Total Overtime Hours			
	1 hour	2 hours	3 hours	4 hours	1 hour	2 hours	3 hours	4 hours
569	5	5	4	4	5	10	12	16
573	7	6	6	6	7	12	18	24
579	16	14	13	13	16	28	39	52
580	16	14	13	13	16	28	39	52
581	16	14	13	13	16	28	39	52
606	11	10	9	8	11	20	27	32
585	16	14	13	13	16	28	39	52
586	16	14	13	13	16	28	39	52
590	16	14	13	13	16	28	39	52
591	16	14	13	13	16	28	39	52
595	16	14	13	13	16	28	39	52
596	16	14	13	13	16	28	39	52
600	11	10	9	8	11	20	27	32
601	11	10	9	8	11	20	27	32
602	**11**	**10**	**9**	**8**	**11**	**20**	**27**	**32**
612	11	10	9	8	11	20	27	32

Source: Analysis Result Data *Microsoft Excel*, 2024

In Table 8. are the calculation results for each total overtime hours from overtime variations of 1 hour, 2 hours, 3 hours and 4 hours. The longer the overtime hours, the faster the work will be.

a. Acceleration Cost Analysis

- **Normal Costs of Daily Workers and Normal Costs of Hourly Workers**

The results of calculating the normal costs of workers per day and the normal costs of workers per hour can be seen in table 9. as follows:

Table 9. Calculation Results of Normal Worker Costs

Job Line Code	Total Cost	Prod. (/Day)	bn (/Day)	Prod. (/Jam)	bn (/Hour)
569	IDR 10,536,199	7,56	IDR 1,756,033.13	1,08	IDR 250,861.88
573	IDR 451,174	0,31	IDR 56,396.73	0,04	IDR 8,056.68
579	IDR 9,319,172	7,57	IDR 517,731.76	1,08	IDR 73,961.68
580	IDR 30,870,101	26,63	IDR 1,715,005.63	3,80	IDR 245,000.80
581	IDR 3,071,236	2,65	IDR 170,624.22	0,38	IDR 24,374.89
606	IDR 3,881,000	0,08	IDR 323,416.67	0,01	IDR 46,202.38
585	IDR 10,241,806	8,32	IDR 568,989.20	1,19	IDR 81,284.17
586	IDR 24,394,118	21,04	IDR 1,355,228.77	3,01	IDR 193,604.11
590	IDR 11,984,186	9,18	IDR 665,788.12	1,31	Rp. 95,112.59
591	IDR 26,125,998	21,26	IDR 1,451,444.34	3,04	IDR 207,349.19
595	IDR 12,210,303	9,18	IDR 678,350.16	1,31	IDR 96,907.17

596	IDR 29,641,184	23,68	IDR 1,646,732.47	3,38	IDR 235,247.50
600	IDR 27,105,812	30,02	IDR 2,258,817.66	4,29	IDR 322,688.24
601	IDR 16,378,562	19,27	IDR 1,364,880.18	2,75	IDR 194,982.88
602	**IDR 32,099,760**	**42,00**	**IDR 2,674,980.00**	**6,00**	**IDR 382,140.00**
612	IDR 14,920,180	0,17	IDR 1,243,348.33	0,02	IDR 177,621.19

Source: Analysis Result Data *Microsoft Excel*, 2024

Table 9. shows the results of calculating normal daily costs and normal hourly costs for each critical path activity using assistance *software Microsoft Excel* 2019.

- **Employee Overtime Costs**

The results of calculating worker overtime costs can be seen in table 4.9 as follows:

Table 10. Overtime Cost Calculation Results

Job Line Code	Overtime Pay 1 hour	Overtime Pay 2 hours	Overtime Pay 3 hours	Overtime Pay 4 hours
569	IDR 376,292.81	IDR 878,016.57	IDR 1,379,740.32	IDR 1,881,464.07
573	IDR 12,085.01	IDR 28,198.37	IDR 44,311.72	IDR 60,425.07
579	IDR 110,942.52	IDR 258,865.88	IDR 406,789.24	IDR 554,712.60
580	IDR 367,501.21	IDR 857,502.82	IDR 1,347,504.42	IDR 1,837,506.03
581	IDR 36,562.33	IDR 85,312.11	IDR 134,061.89	IDR 182,811.67
606	IDR 69,303.57	IDR 161,708.33	IDR 254,113.10	IDR 346,517.86
585	IDR 121,926.26	IDR 284,494.60	IDR 447,062.94	IDR 609,631.29
586	IDR 290,406.17	IDR 677,614.39	IDR 1,064,822.61	IDR 1,452,030.83
590	IDR 142,668.88	IDR 332,894.06	IDR 523,119.24	IDR 713,344.41
591	IDR 311,023.79	IDR 725,722.17	IDR 1,140,420.55	IDR 1,555,118.93
595	IDR 145,360.75	IDR 339,175.08	IDR 532,989.41	IDR 726,803.74
596	IDR 352,871.24	IDR 823,366.24	IDR 1,293,861.23	IDR 1,764,356.22
600	IDR 484,032.36	IDR 1,129,408.83	IDR 1,774,785.30	IDR 2,420,161.78
601	IDR 292,474.33	IDR 682,440.09	IDR 1,072,405.86	IDR 1,462,371.63
602	**IDR 573,210.00**	**IDR 1,337,490.00**	**IDR 2,101,770.00**	**IDR 2,866,050.00**
612	IDR 266,431.79	IDR 621,674.17	IDR 976,916.55	IDR 1,332,158.93

Source: Analysis Result Data *Microsoft Excel*, 2024

Table 10. shows the results of calculating overtime costs for critical path activities with varying durations of 1 hour, 2 hours, 3 hours and 4 hours using assistance. *software Microsoft Excel* 2019.

- **Crash Cost**

The calculation results *crash cost* can be seen in table 4.10 as follows:

Table 11. Crash Cost Calculation Results

Job Line Code	*Crash Cost*			
	1 hour	2 hours	3 hours	4 hours
569	IDR 8,780,165.67	IDR 8,780,165.67	IDR 7,024,132.53	IDR 7,024,132.53
573	IDR 394,777.14	IDR 338,380.40	IDR 338,380.40	IDR 338,380.40
579	IDR 8,283,708.16	IDR 7,248,244.64	IDR 6,730,512.88	IDR 6,730,512.88
580	IDR 27,440,090.10	IDR 24,010,078.84	IDR 22,295,073.20	IDR 22,295,073.20
581	IDR 2,729,987.56	IDR 2,388,739.11	IDR 2,218,114.89	IDR 2,218,114.89
606	IDR 3,557,583.33	IDR 3,234,166.67	IDR 2,910,750.00	IDR 2,587,333.33
585	IDR 9,103,827.20	IDR 7,965,848.80	IDR 7,396,859.60	IDR 7,396,859.60
586	IDR 21,683,660.32	IDR 18,973,202.78	IDR 17,617,974.01	IDR 17,617,974.01
590	IDR 10,652,609.92	IDR 9,321,033.68	IDR 8,655,245.56	IDR 8,655,245.56

Job Line Code	*Crash Cost*			
	1 hour	2 hours	3 hours	4 hours
591	IDR 23,223,109.40	IDR 20,320,220.73	IDR 18,868,776.39	IDR 18,868,776.39
595	IDR 10,853,602.56	IDR 9,496,902.24	IDR 8,818,552.08	IDR 8,818,552.08
596	IDR 26,347,719.55	IDR 23,054,254.61	IDR 21,407,522.14	IDR 21,407,522.14
600	IDR 24,846,994.26	IDR 22,588,176.60	IDR 20,329,358.94	IDR 18,070,541.28
601	IDR 15,013,682.02	IDR 13,648,801.83	IDR 12,283,921.65	IDR 10,919,041.47
602	**IDR 29,424,780.00**	**IDR 26,749,800.00**	**IDR 24,074,820.00**	**IDR 21,399,840.00**
612	IDR 13,676,831.67	IDR 12,433,483.33	IDR 11,190,135.00	IDR 9,946,786.67

Source: Analysis Result Data *Microsoft Excel*, 2024

Table 11 shows the calculation results *crash cost* of each critical path activity with varying durations of 1 hour, 2 hours, 3 hours and 4 hours using the help of *software Microsoft Excel* 2019.

- **Daily Cost Slope and Accelerated Cost Slope**

The calculation results *cost slope* per day and *cost slope* acceleration can be seen in table 4.11 as follows:

Table 12. Calculation Results of Daily Cost Slope and Acceleration Cost Slope Duration 4 hours

Job Line Code	Normal Duration (days)	*Crash Duration* (day)	*Duration Variance* (day)	*Cost Slope* (/day)	*Cost Slope* Acceleration
569	6	4	2	IDR 2,634,049.70	IDR 5,268,099.40
573	8	6	2	IDR 140,991.83	IDR 281,983.67
579	18	13	5	IDR 1,242,556.22	IDR 6,212,781.12
580	18	13	5	IDR 4,116,013.51	IDR 20,580,067.57
581	18	13	5	IDR 409,498.13	IDR 2,047,490.67
606	12	8	4	IDR 565,979.17	IDR 2,263,916.67
585	18	13	5	IDR 1,365,574.08	IDR 6,827,870.40
586	18	13	5	IDR 3,252,549.05	IDR 16,262,745.24
590	18	13	5	IDR 1,597,891.49	IDR 7,989,457.44
591	18	13	5	IDR 3,483,466.41	IDR 17,417,332.05
595	18	13	5	IDR 1,628,040.38	IDR 8,140,201.92
596	18	13	5	IDR 3,952,157.93	IDR 19,760,789.66
600	12	8	4	IDR 3,952,930.91	IDR 15,811,723.62

Job Line Code	Normal Duration (days)	*Crash Duration* (day)	*Duration Variance* (day)	*Cost Slope* (/day)	*Cost Slope* Acceleration
601	12	8	4	IDR 2,388,540.32	IDR 9,554,161.28
602	**12**	**8**	**4**	**IDR 4,681,215.00**	**IDR 18,724,860.00**
612	12	8	4	IDR 2,175,859.58	IDR 8,703,438.33
Total				**IDR 37,587,313.73**	**IDR 165,846,919.05**

Source: Analysis Result Data *Microsoft Excel*, 2024

Table 12. shows the calculation results *cost slope* per day and *cost slope* of each critical path activity with a varying duration of 4 hours using assistance *software Microsoft Excel* 2019.

- ***Cost Variance***

The calculation results *cost variance* can be seen in table 4.12 as follows:

Table 13. Cost Variance Calculation Results

Job Line Code	*Cost Variance*			
	1 hour	2 hours	3 hours	4 hours
569	-Rp 1,756,033.13	-Rp 1,756,033.13	-Rp 3,512,066.27	-Rp 3,512,066.27
573	-Rp 56,396.73	-Rp 112,793.47	-Rp 112,793.47	-Rp 112,793.47
579	-Rp 1,035,463.52	-Rp 2,070,927.04	-Rp 2,588,658.80	-Rp 2,588,658.80
580	-Rp 3,430,011.26	-Rp 6,860,022.52	-Rp 8,575,028.16	-Rp 8,575,028.16
581	-Rp 341,248.44	-Rp 682,496.89	-Rp 853,121.11	-Rp 853,121.11
606	-Rp 323,416.67	-Rp 646,833.33	-Rp 970,250.00	-Rp 1,293,666.67
585	-Rp 1,137,978.40	-Rp 2,275,956.80	-Rp 2,844,946.00	-Rp 2,844,946.00
586	-Rp 2,710,457.54	-Rp 5,420,915.08	-Rp 6,776,143.85	-Rp 6,776,143.85
590	-Rp 1,331,576.24	-Rp 2,663,152.48	-Rp 3,328,940.60	-Rp 3,328,940.60
591	-Rp 2,902,888.68	-Rp 5,805,777.35	-Rp 7,257,221.69	-Rp 7,257,221.69
595	-Rp 1,356,700.32	-Rp 2,713,400.64	-Rp 3,391,750.80	-Rp 3,391,750.80
596	-Rp 3,293,464.94	-Rp 6,586,929.89	-Rp 8,233,662.36	-Rp 8,233,662.36
600	-Rp 2,258,817.66	-Rp 4,517,635.32	-Rp 6,776,452.98	-Rp 9,035,270.64
601	-Rp 1,364,880.18	-Rp 2,729,760.37	-Rp 4,094,640.55	-Rp 5,459,520.73
602	**-Rp 2,674,980.00**	**-Rp 5,349,960.00**	**-Rp8,024,940.00**	**-Rp 10,699,920.00**
612	-Rp 1,243,348.33	-Rp 2,486,696.67	-Rp 3,730,045.00	-Rp 4,973,393.33

Source: Analysis Result Data, 2024

Table 13 shows the results of the calculations *cost variance* with variations in the duration of overtime hours of 1 hour, 2 hours, 3 hours and 4 hours of each critical path activity. The calculation results *cost variance* shows negative, then this means the work was completed late and cost more than the budget.

b. Recalculation Analysis *Critical Path Method* (CPM)

After calculating the acceleration of duration on critical path activities accompanied by calculating additional costs for overtime working hours, rescheduling is carried out using the application *microsoft project* 2019 by having project results experience a reduction in life. However, the results are recalculated using the application *microsoft project* 2019 by adding variations in overtime duration of 1 hour shows that critical path activities have not changed, this also happens when recalculations are carried out with variations in overtime duration of 2 hours and 3 hours. So a recalculation will be carried out by adding an overtime duration of 4 hours which shows that the results of critical path activities are not critical, so with this the project will be able to be implemented faster than the normal duration, namely 248 days to 183 with a difference of 65 days. After that, direct cost calculations will be carried out which can be seen as follows:

- **Direct cost**

The results of direct cost calculations can be seen in table 4.13 as follows:

Table 14. Direct Cost Calculation Results Overtime Duration 4 hours

Job Line Code	Duration			Cumulative Duration	*Cost Variance*	Direct cost
	Normal	*Crash*	Difference			
				248		**IDR 263,230,790.91**
569	6	4	2	246	-Rp 3,512,066.27	IDR 266,742,857.17
573	8	6	2	244	-Rp 112,793.47	IDR 266,855,650.64
579	18	13	5	239	-Rp 2,588,658.80	IDR 269,444,309.44
580	18	13	5	234	-Rp 8,575,028.16	IDR 278,019,337.60
581	18	13	5	229	-Rp 853,121.11	IDR 278,872,458.71
606	12	8	4	183	-Rp 1,293,666.67	IDR 280,166,125.37
585	18	13	5	224	-Rp 2,844,946.00	IDR 283,011,071.37
586	18	13	5	219	-Rp 6,776,143.85	IDR 289,787,215.22
590	18	13	5	214	-Rp 3,328,940.60	IDR 293,116,155.82
591	18	13	5	209	-Rp 7,257,221.69	IDR 300,373,377.51
595	18	13	5	204	-Rp 3,391,750.80	IDR 303,765,128.31
596	18	13	5	199	-Rp 8,233,662.36	IDR 311,998,790.67
600	12	8	4	195	-Rp 9,035,270.64	IDR 321,034,061.31
601	12	8	4	191	-Rp 5,459,520.73	IDR 326,493,582.05
602	**12**	8	4	**187**	-Rp 10,699,920.00	IDR 337,193,502.05
612	12	8	4	183	-Rp 4,973,393.33	IDR 342,166,895.38

Source: Analysis Result Data, 2024

Table 14 shows the results of increasing direct costs from 4 hours overtime of IDR 263,230,790.91 to IDR 342,166,895.38. For a graph of the relationship between the direct costs of 4 hours of overtime and the cumulative duration, it can be seen in Figure 4.2 as follows:

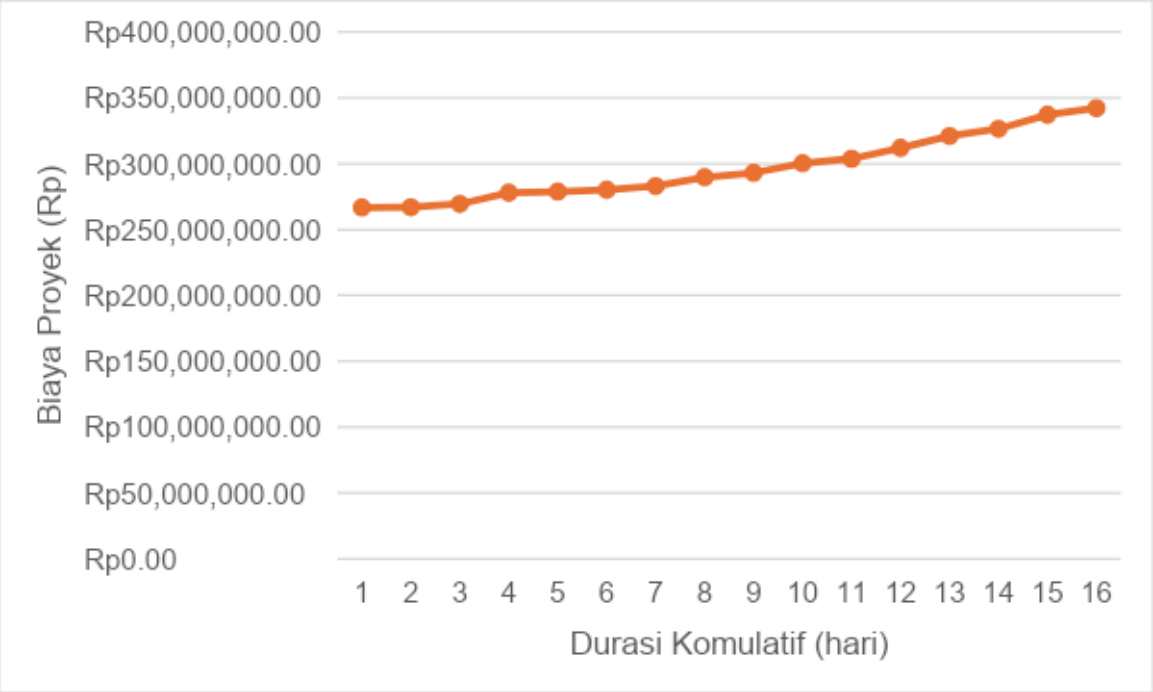


Figure 3. 4 Hour Overtime Direct Cost Chart
Source: Analysis Result Data *Microsofts Excel*, 2024

Figure 3. shows that direct costs increased after acceleration. The increase is based on additional working hours which makes costs even greater. In the normal duration, direct costs in 248 days amounting to IDR 263,230,790.91 have increased to IDR 342,166,895.38 with a cumulative duration of 183 days.

- **Time efficiency**

  To obtain time efficiency, calculations can be carried out using equation 2.17 attached to CHAPTER 2, as follows:

  And = project duration-cumulative durationproject durationx100%
  = 248-187248x100%=0.245%

  So from time efficiency calculations, in the Kerobokan Bali Parking Building construction project there has been a change in duration of 0.245% from the normal duration.

- **Cost Efficiency**

  Cost efficiency is the percentage of project duration due to acceleration. To obtain time efficiency, calculations can be carried out using equation 2.18 attached to CHAPTER 2, as follows:

  Ec = Project total cost-Cumulative total costTotal project costsx100%
  = IDR 8,822,280,000.00 - IDR 342,166,895.38IDR 8,822,280,000.00x100%=0.961%

  So from cost efficiency calculations, in the Kerobokan Bali Parking Building construction project there has been an increase of 0.961%.

c. Recalculation Analysis *Critical Path Method* (CPM)

After all the explanations of the results of variations in additional working hours, the following is a comparison between normal time and costs and the time and costs of overtime work with a duration of 4 hours which can be seen in table 4.14 as follows:

Table 15. Comparison of Cost and Time for Normal Conditions and 4 Hour Overtime

Variation	Duration	Direct cost	Cost Difference
Normal	248	IDR 263,230,790.91	-
Overtime 4 hours	187	IDR 342,166,895.38	IDR 78,936,104.47

Source: Analysis Result Data *Ms. Excel*, 2024

Table 4.14 shows the increase in costs and decrease in overtime hours with a duration of 4 hours relative to time and costs. You can see the shortening of time where the duration is shortened to 187 days from the normal duration of 248 days with a cost difference of IDR 78,936,104.47. From table 4.14, a

comparison of costs between normal conditions and additional working hours (overtime work duration of 4 hours) will be presented which can be seen in figure 4.3 as follows:

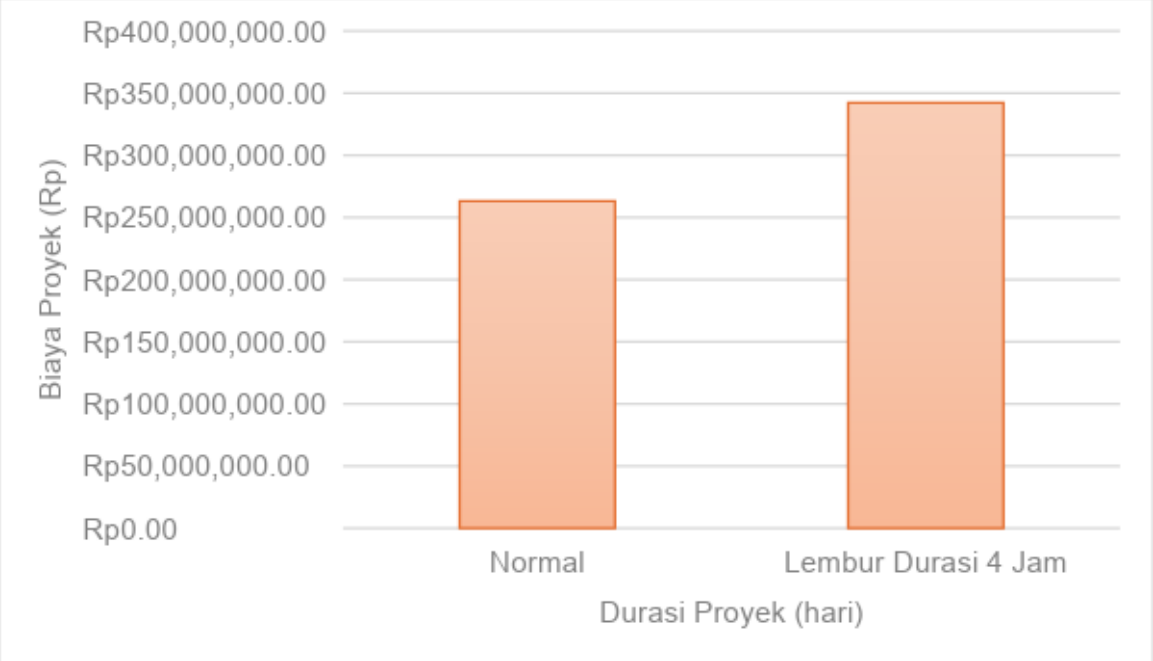


Figure 4. Comparison Chart of Acceleration Time and Costs
Source: Analysis Result Data *Microsofts Excel*, 2024

Figure 4. shows the difference in costs for additional working hours (overtime work). It can be seen in the diagram that costs tend to increase from normal costs and 4 hours overtime. It can be concluded that additional working hours (overtime work) will have a direct impact on the direct costs of a project.

d. Research result

Based on all the calculations above starting with subchapter 4.4 to subchapter 4.6, it can be seen that the Kerobokan Bali Parking Building Construction project can be completed within a period of 248 working days with a total cost of IDR 8,822,280,000.00 (under normal conditions), then analysis is carried out with the Microsoft Project 2019 assistance application to find out the activities included in the critical path of all work items. From these critical path activities, acceleration (crashing) can be carried out using additional overtime working hours. From Figure 4.9 it can be seen that there are 16 activities that fall into the critical path.

After knowing the critical path activities that will be accelerated, the crash duration and cost slope of each critical path activity are determined with the aim of determining duration cuts and cost increases. The project life efficiency is 0.245% with an acceleration difference of 61 working days and the acceleration (crashing) duration is 187 working days with a total cost of IDR 8,901,216,104.5 with a cost efficiency of 0.961%.

CONCLUSION

Based on case studies that have been carried out on the Kerobokan Bali Parking Building Construction project accompanied by discussion analysis with the title application of the CPM method (*Critical Path Methode*) on the construction project several conclusions were obtained, namely:

1. Based on the total duration of all activities and linking each activity with a logical dependency relationship coupled with CPM calculation analysis (*Critical Path Methode*) with the help application *microsoft project* In 2019, there was a list of 16 activities included in the critical path activities, namely activities that have the following line codes:
   a. 569 = Plafon Gibsum Board, t: 9 mm + Rangka Hollow Galvalume
   b. 573 = UnPolisd Floor Ceramics, UK. 20 x 20 cm
   c. 579 = New Mowilex Exterior Wall Painting
   d. 580 = New Painting of Mowilex Internal Walls
   e. 581 = New Ceiling Painting in Mowilex White
   f. 606 = Alm Frame / Door + Glass, P-1 (uk.80x226 cm)
   g. 585 = New Mowilex Exterior Wall Painting
   h. 586 = New Painting of Mowilex Internal Walls

i. 590 = New Mowilex Exterior Wall Painting
j. 591 = New Painting of Mowilex Internal Walls
k. 595 = New Mowilex Exterior Wall Painting
l. 596 = New Painting of Mowilex Internal Walls
m. 600 = New Mowilex Exterior Wall Painting
n. 601 = New Painting of Mowilex Internal Walls
o. 602 = Painting *Waterprofing* With Membrane Fiber
p. 612 = Alm Frame / Door / Window + Glass, PJ-2 (uk.228x226 cm)

After analyzing the acceleration of duration using the method of adding 4 hours of overtime working hours and rescheduling using the application *microsoft project* In 2019, it was found that the cost efficiency percentage was 0.961% with a duration of 187 working days.

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