

Selection of Alternative Working Methods using the Crashing and Microsoft Project Methods

Muhammad Djuneydi, Yudi Setio Prabowo, M. Oka Mahendra



Abstract: In carrying out the PPLP Banten Building construction project, it experienced delays. The causes of delays are the addition of time, changes in shop drawings and material delays. Then the solution in the Microsoft project is an alternative crashing method of 4 hours of overtime and work shifts. The research results obtained 18 jobs that are on the critical path of 43 jobs. The normal total duration is 942 days and the normal fee is Rp. 569.100.000 using AHSP. The results obtained are the total duration of the alternative crashing 4 hours of overtime work is 678 days, while the work shift is 530 days, the AHSP Project produces an alternative total cost of 4 hours overtime of Rp. 3.066.675.000 and work shifts with accident costs of Rp. 1.223.565.000. The alternative cost of 4 hours of overtime using the AHSP project is Rp. 193.067.245,23 and work shifts using the AHSP project of Rp. 33.638.199,58 then the work shift alternative is more economical and was chosen to be applied to the project. The results of the comparison of direct and indirect costs for the 4-hour overtime alternative are direct costs Rp. 9.672.161.032,2 indirect costs Rp. 1.322.728.805,77 and direct costs for work shift alternatives Rp. 9.512.731.986,58 costs Rp. 1.273.456.116,78 then the work shift alternative is more economical and is chosen to be applied to the project.

Keywords: Microsoft Project, Crashing, Overtime, Shifts, Time, Costs.

I. INTRODUCTION

In a construction project there is a priority in the success of control, namely scheduling. Construction management plays an important role in the success of a construction project. Cost, quality and time are the benchmarks that form the basis of construction management control. The problem that often occurs during planning during field implementation is that if communication between the planner and the executor is not well developed, it becomes a problem of inhibiting the performance of construction projects.

When viewed from the inhibition of construction projects during implementation, it is not only seen from one factor, but there are several factors including conditions and situations in the field, unfavorable weather changes, changes in planning design and delays in arriving materials, slowing down activities. Acceleration of project time is often done when the project progress is judged to have delayed the plan. In addition, time acceleration can also be done at the time of planning. But the acceleration of time has an impact on costs, quality, and risk. Therefore, the acceleration of project implementation time must be planned with careful consideration. The occurrence of delays during project construction resulted in cost overruns and the project was not completed on time. Therefore, in an effort to succeed in a construction project, good management is needed in increasing efficiency, productivity and quality of work so that project monitoring and control measures can overcome problems that occur due to delays in the project.

The object to be studied and to be analyzed in this study is the Banten Province PPLP (Student Sports Education and Training Center) building project for the 2020 fiscal year. Located on Jl. Raya Cilegon No. 517, Kel. Drangong, Kec. Takakan, City of Serang, Banten 42162 which was built by PT. Respati Jaya Pratama and PT. Bighi Prakasa Consultants, where during the construction of this project there were delays caused by several factors including the weather factor, changes to the foundation design on the plan, namely bored piles were replaced with piles, the arrival of the material to be used, namely piles because the project construction occurred during a pandemic Covid-19. In planning, the Banten Province PPLP (Student Sports Education and Training Center) building project should have started on May 6 2020 with 180 calendar days, but due to many obstacles this project was delayed to 225 calendar days. Therefore, the completion of project delays must be accelerated in controlling duration and costs. If the acceleration of scheduling is not carried out, this project will experience cost overruns plus fines in the agreement between the owner and the contractor because it is not in accordance with the agreement. Costs increase from paying labor wages to get effectiveness from productivity in order to accelerate project scheduling by using the crashing method which aims to get the job done by exchanging cross between time and costs both directly and indirectly. Through research, [1] discusses the analysis of project acceleration using the crashing method with the addition of four hours and a work shift system but does not use the Microsoft project for scheduling and calculates worker wages using only the project's AHSP.

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The researcher differentiates, namely the application of the crashing method by using an alternative of 4 hours of overtime work and work shifts by comparing the price of labor wages using the AHSP project.

The process uses assistive devices, namely Microsoft project software to adjust the relationship between workers who are on the critical cross or (Critical Path) project. Acceleration is carried out to find out during normal project conditions and after acceleration using an alternative of 4 hours of overtime and work shifts that have the most efficient duration and the most economical work costs to apply to this project

II. MICROSOFT PROJECT AND CRASHING

A. Microsoft Project

According to Syafrandi & Putri Lynna A. Luthan (2021) the book in a construction management book with a Microsoft project application, it defines that a Microsoft project is an application program or computer software that is used to schedule projects, especially construction projects. Microsoft Project helps record and monitor the use of resources, whether in the form of human resources, equipment, or materials. This application can also record labor requirements in each activity sector, record employee working hours, overtime hours, and calculate expenses for labor costs in several activities. This program can present reports on each position in accordance with the developments that occur in the project.

B. Crashing

According to Frederika (2010) in [1] Speeding up project completion time is an attempt to finish the project earlier than the completion time under normal circumstances by holding this project acceleration there will be a reduction in the duration of activities that will be held by a crash program. The maximum crashing duration of an activity is the shortest duration for completing an activity that is technically still possible assuming the resource is not a bottleneck. The maximum acceleration duration is limited by the size of the project or work location, but there are four factors that can be optimized to carry out acceleration in an activity which include increasing the number of workers, scheduling overtime work, using heavy equipment and changing construction methods in the field.

1. 4 Hours of Overtime

In project activities, overtime sometimes has to be done under certain conditions. If overtime occurs, workers have more time to work than the normal duration that has been determined. Overtime work time is work time that exceeds 7 hours a day for 6 working days and 40 hours a week or 8 hours a day for 8 working days and 40 hours a week or working time on weekly rest days and or on official holidays stipulated by Government Regulations Number 35 of 2021 Article 26 Paragraph 1 and according to the Labor Law Article 78 No. 13 of 2003 provisions for employee overtime are as follows:

- 1) Maximum overtime for workers is only 14 hours in one week.
- 2) Overtime work for employees may be done for a maximum of 4 hours in one day, so no more than 4 hours in one day.

The existence of overtime working hours of workers resulted in decreased work efficiency, due to factors of overtime

hours. According to Thomas (2002) in [2], every time work or working hours exceed 40 hours per week is unavoidable, for example to catch up with schedules even though this will reduce work efficiency. In this case, a graph is made that shows productivity decreases when the number of hours per day and per week increases

2. Shift work

Shift work is a work arrangement system that provides an opportunity to utilize all available time to operate work. Shift work is a work schedule where workers work alternately so that operational activities continue. Shifts are related to a lack of efficient communication between workers, as well as poor health conditions due to a lack of rest hours due to changing sleep cycle times. The division of morning, afternoon and evening work shifts has been regulated in Law [3] concerning Manpower Article 79 paragraph 2 letter a.

The article explains that working hours within a company or other legal entity are determined in 3 (three) shifts, and the distribution for each shift is a maximum of 8 hours per day (including work breaks). When accumulated, the total work of each shift may not exceed 40 hours a week. Excess working hours of employees must be known and with an order (written) from the leadership (management) of the company which is calculated as overtime. Meanwhile, how many hours are worked for each shift, the government gives freedom to companies to regulate it. Companies can regulate this themselves in Work Agreements (PK), Company Regulations (PP), and Collective Labor Regulations (PKB) as long as they do not exceed the working hours set by the Government in the Law. The function of this alternative shift is to help minimize the workload received by workers/carpenters. However, to make this alternative shift, it must be adjusted to the regulations and costs that will be used.

Factors that affect shift work hours include the following:

- 1) Unsupportive environmental conditions can affect work shifts, such as noise, awareness of workers in using PPE while working.
- 2) The rotational work system can also affect work shifts which can cause rhythm changes, especially for night shift workers.
- 3) Age (the older a person is, the higher a person's fatigue level will be).
- 4) Health or illness owned.
- 5) Gender.
- 6) Education.
- 7) Workload and length of service

C. RAB

According to Ibrahim (2003) in [4] journal accelerated project scheduling EPCC Pier C PT. Petrokimia Gresik with the fast track method that the budget plan (Bergrooting) of a building or project is the calculation of the amount of costs required for materials and wages and other costs related to the implementation of the building or project. The budgeted cost is the price of the building which is calculated carefully, accurately and meets the requirements.



The budget for the same building will vary in each region, due to differences in material prices and labor wages. Make a Work Unit Price Analysis (AHSP): is an analysis of the calculation of the cost of unit price requirements for wages, materials and rental of heavy equipment to obtain a price per one unit of work volume, the AHSP itself consists of price descriptions, coefficients, wage unit prices, materials and tools, the product of the coefficient and the unit price. The coefficient value can be seen through national government regulations such as SNI or regional government regulations, and the product is added up and becomes the unit price.

1. Direct Cost

According to Syafriandi & Luthan (2017) in the book defines that direct costs are costs that directly affect the physical implementation of the project, they can also be called labor costs. The direct costs include:

- a) Cost of materials, taking into account the specifications, quality and quantity of materials needed can be calculated for the cost of materials.
- b) Labor costs, these costs are calculated by estimating the expertise and amount used to carry out each project activity.
- c) Subcontractor costs are costs incurred for certain activities carried out by other parties.
- d) Cost of equipment, in general projects the cost of this equipment is classified as a type of own cost, this cost can be a rental or equipment depreciation expense.

2. Indirect Cost

According to Syafriandi & Luthan (2017) in the book defines that indirect costs are expenses for management, where these costs are incurred to be able to expedite project implementation, these costs include:

- a) General project costs, which include these costs, for example the cost of constructing temporary facilities, employee salaries, provision of transportation, electricity, water and others.
- b) Profits, these costs are usually taken into account to complete the project bid.

Indirect costs are costs associated with supervisory, administrative, consulting, work direction, interest and unexpected costs (overhead costs), profits and cost overruns. This indirect cost does not depend on the volume of work that depends on the project implementation period. This indirect cost will increase if the implementation time is longer. The elements contained in these costs include, for example, employee salaries, general office costs, costs of procuring public facilities.

a. Profit

For profit + overhead calculations, a maximum of 15% is commonly used as stated in the elucidation of Presidential Regulation No. 70 of 2012 Article 66 Paragraph 8 HSP is prepared by taking into account profits and overhead costs which are considered reasonable.

According to Nafarin (2017) in the book Profit is income with a balance of costs and expenses for a certain period. In general, profit is the total revenue minus the total costs. Profit can be said as the excess income above in return for producing goods and services during one period. In the world of construction projects that have a profit standard in the form of a percentage, the Indonesian government suggests that the

general standard of profit from a project is 10% of the project implementation price [5]. However, this 10% profit is not a standard, it can be adjusted according to the contract value of the project.

b. Overheads

Overhead, namely as an indirect cost because overhead is a cost that is taken into account in the analysis of certain unit prices, this overhead is divided into two types, goods overhead according to Presidential Regulation No. 70 of 2012 Article 1 Paragraph 14 is every object, both tangible and intangible, movable or immovable, which can be traded, used or utilized by the user of the goods. Overhead for goods is calculated based on a comparison of the cost component of the specifications required with the specifications offered by the goods market, additional insurance facilities and so on.

Then secondly there is service overhead in general with the definition of the Work Unit Price Analysis (AHSP) in the Public Works Sector, which explains that overhead is a general cost. Costs that are not directly incurred to support the realization of the work in question or costs that are calculated as operational costs include expenses for office costs, management costs (bank interest, bank guarantees, tenders) licensing and medical expenses. This overhead cost is calculated based on a percentage of direct costs, the amount of which depends on the length of time the work is carried out, the amount of the prevailing interest rate and soon.

III. METHODOLOGY AND RESULTS

This study describes the analysis of accelerated project scheduling in which the duration of the project is accelerated by means of 4 hours of overtime and work shifts. The goal is to get the change between cost and time which will be analyzed using Microsoft project software.

A. Research Instruments

Accelerating the duration of the project by means of 4 hours of overtime and work shifts requires primary and secondary data. Primary data obtained from further observations, interviews, documentation. Meanwhile, secondary data for this study were obtained from previous studies. Among them in this study are project general data, S-curve, RAB, BOQ, project AHSP.

B. Flow Chart

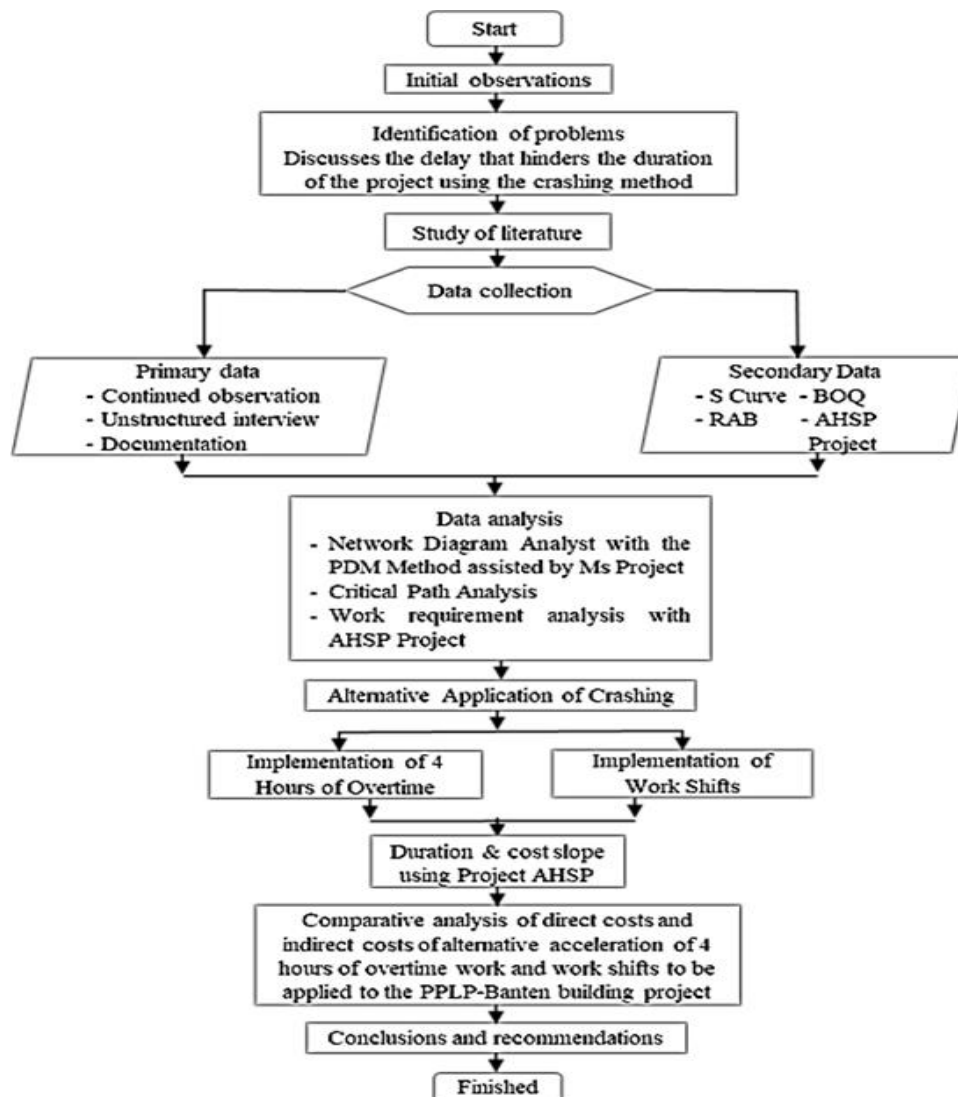


Figure 1. Flow Chart (Source: Processed Alone)

C. Normal Duration Analysis

Jobs that experience delays are heavily influenced by two factors, namely internal and external factors including the following:

- 1) There is a delay in materials in the field, namely pile to the project site.
- 2) Changes to shop drawings in the field on the boredpile foundation are changed to pile cap foundations which require preparation for these changes.
- 3) Delays in the PPLP Banten 2020 building project resulted in an additional planned time of 180 calendar days to 225 calendar days.

To be able to solve problems on project duration with available time, it is necessary to act, namely accelerating the implementation schedule for several activities that are on the critical path using the crashing method. After getting any work that is on the critical path, then it will be calculated using the two alternatives that have been selected in this study, namely, the alternative of adding 4 hours of overtime work and working shifts. Then to be able to help find the results of the total duration of crashing, project data such as normal duration & volume of work that experience delays on the critical path are needed.

D. Determination of Labor Needs

After analyzing the several jobs on the critical path in the network diagram, the next step is to analyze the acceleration of the 18 jobs that are on the critical path. In analyzing the 18 jobs, starting from calculating the number of labor requirements for the 18 jobs that are on the critical path. What must be done is the need for project data which is used to calculate labor requirements for 18 jobs on the critical path with project data such as coefficient values and daily wages in the project Unit Price Analysis with tools using Microsoft Excel. According to [6] to calculate the number of workers per day using the following formula:



Volume x koefisien

Number of workers per day = normal duration (1)

Table 1. Daily Labor Requirements Using The Crashing Method

No	Work	Number Of Workers Per Day (Person)				amount
		Worker	Craftsman	Foreman	Foreman	
1	Preparatory Work	1			1	2
2	Excavation Of Soil, Fill & Foundation Floor 1	16			1	17
3	Concrete Structure & Foundation Work 1st Floor	3	1	1	1	6
4	Floor Concrete Work 2	6	2	1	1	10
5	Floor Concrete Work 3	3	1	1	1	6
6	1st Floor Sill Work	1	1	1	1	4
7	1st Floor Work	13	7	1	1	22
8	1st Floor Painting Work	2	4	1	1	8
9	2nd Floor Sill Work	1	1	1	1	4
10	3rd Floor Roof & Ceiling Work	5	2	1	1	9
11	3rd Floor Painting Work	2	4	1	1	8
12	2nd Floor Sanitation Work	1	1	1	1	4
13	3rd Floor Sanitation Works	1	1	1	1	4
14	1st Floor Electrical Installation Work	2	2	1	1	6
15	2nd Floor Electrical Installation Work	3	3	1	1	8
16	3rd Floor Electrical Installation Work	2	2	1	1	6
17	Other Jobs	1			1	2
18	Install Concrete Panel Fence	2	1	1	1	5
Total						131

According to [6] to calculate labor wages using the following formula:

Wages per day of labor = *Number of workers per day x daily wages of workers.....* (2)

Total Daily Costs = *Total wages per day of labor* (3)

Total Cost = *Total daily cost x Duration.....* (4)

Table 2. Daily Costs and Total Costs of Work with AHSP Projects

No	Work	Total Daily Cost	Total Cost Of Work
1	Preparatory Work	Rp 205.000	Rp 46.125.000
2	Excavation Of Soil, Fill & Foundation Floor 1	Rp 1.480.000	Rp 41.440.000
3	Concrete Structure & Foundation Work 1st Floor	Rp 585.000	Rp 32.760.000
4	Floor Concrete Work 2	Rp 940.000	Rp 46.060.000
5	Floor Concrete Work 3	Rp 585.000	Rp 36.855.000
6	1st Floor Sill Work	Rp 415.000	Rp 14.525.000
7	1st Floor Work	Rp 2.035.000	Rp 99.715.000
8	1st Floor Painting Work	Rp 800.000	Rp 28.000.000
9	2nd Floor Sill Work	Rp 415.000	Rp 14.525.000
10	3rd Floor Roof & Ceiling Work	Rp 855.000	Rp 41.895.000
11	3rd Floor Painting Work	Rp 800.000	Rp 28.000.000
12	2nd Floor Sanitation Work	Rp 415.000	Rp 15.355.000
13	3rd Floor Sanitation Works	Rp 415.000	Rp 15.355.000
14	1st Floor Electrical Installation Work	Rp 600.000	Rp 27.000.000
15	2nd Floor Electrical Installation Work	Rp 785.000	Rp 22.765.000
16	3rd Floor Electrical Installation Work	Rp 600.000	Rp 27.000.000
17	Other Jobs	Rp 205.000	Rp 9.225.000
18	Install Concrete Panel Fence	Rp 500.000	Rp 22.500.000
Total Cost		Rp 827.120.000	Rp 569.100.000



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Accelerating Crashing Using Alternative 4 Hours of Overtime

1. Productivity 4 Hours of Overtime According to [6]

$$\text{Productivity per day} = \frac{\text{Volume}}{\text{normal duration}} \dots\dots\dots (5)$$

$$\text{Workforce Productivity} = \frac{\text{Productivity per day}}{\text{number of workers}} \dots\dots\dots (6)$$

$$\text{Normal Productivity Per hour} = \frac{\text{Prod.Labor}}{\text{Normal working hours per day}} \dots\dots\dots (7)$$

$$\text{Normal productivity 4 Hours} = \text{Prod. Normal Hourly} \times \text{Additional Hours Duration (4 Hours)} \frac{\text{Normal Product}}{1,1} \dots\dots\dots (8)$$

$$\text{Prod. 1st Hour Overtime} = \frac{\text{Normal Product}}{1,2} \dots\dots\dots (9)$$

$$\text{Prod. 2nd Hour Overtime} = \frac{\text{Normal Product}}{1,3} \dots\dots\dots (10)$$

$$\text{Prod. 3rd Hour Overtime} = \frac{\text{Normal Product}}{1,4} \dots\dots\dots (11)$$

$$\text{Prod. 4th Hour Overtime} = \dots\dots\dots (12)$$

Total Overtime Productivity 4 Hours

= First Hour + Second Hour + Third Hour

+ Fourth Hour (13)

$$\text{Labor Efficiency} = \frac{\text{Total Prod.4 hours}}{\text{Normal Prod.4 hours}} \times 100\% \dots\dots\dots (14)$$

Productivity Decline

$$= 1 - \text{labor effectiveness} \dots\dots\dots (15)$$

2. Alternative Crash Duration 4 Hours Overtime

To get the crash duration for the alternative of 4 hours of overtime, according to [6] to calculate labor wages using the following formula.

$$\text{Crash duration} = \frac{(Dn \times h)}{(h + (ho \times e))} \dots\dots\dots (16)$$

note:

Dn = normal duration ho = total number of overtime hours h = Number of normal working hours e = labor efficiency

Table 3. Summary of Alternative Crash Duration 4 Hours of Overtime Work

No	Work	Normal Duration	CrashDuration
1	Preparatory Work	225	161
2	Excavation Of Soil, Fill & Foundation Floor 1	28	20
3	Concrete Structure & Foundation Work 1st Floor	56	40
4	Floor Concrete Work 2	49	35
5	Floor Concrete Work 3	63	45
6	1st Floor Sill Work	35	25
7	1st Floor Work	49	35
8	1st Floor Painting Work	35	25
9	2nd Floor Sill Work	35	25
10	3rd Floor Roof & Ceiling Work	49	35
11	3rd Floor Painting Work	35	25
12	2nd Floor Sanitation Work	37	27
13	3rd Floor Sanitation Works	37	27
14	1st Floor Electrical Installation Work	45	33
15	2nd Floor Electrical Installation Work	29	21
16	3rd Floor Electrical Installation Work	45	33
17	Other Jobs	45	33
18	Install Concrete Panel Fence	45	33
Total		942	678



3. Alternative Crash Costs 4 Hours of Overtime

Government Regulation Number 35 of 2021 Article 26 Paragraph 1[7], namely 4hours of overtime is only allowed a maximum of up to 4 hours in 1 day. Thenin the calculation of overtime hours wages enter into the formula as follows:

- First overtime hour wage
= 1.5 x normal hourly wage..... (17)

- Second overtime hour wage
= 2 x normal wage per hour (18)

- Third overtime hour wage
= 2 x normal wage per hour (19)

- Fourth overtime hour wage
= 2 x normal wage per hour..... (20)

- Total overtime pay per day
= Total first overtime pay + Second overtime amount +Third overtime amount + Total fourth overtime (21)

- Daily wages = Total labor wages per day x Number of workers (22)

According to [6]

Crash Cost = Total labor wage per day x crash duration (23)

Table 4. Crash Cost Alternative 4 Hours of Overtime using Project AHSP

No	Work	Normal Cost	Crash Cost
1	Preparatory Work	Rp 46.125.000	Rp 247.537.500
2	Excavation Of Soil, Fill & Foundation Floor 1	Rp 41.440.000	Rp 222.000.000
3	Concrete Structure & Foundation Work 1st Floor	Rp 32.760.000	Rp 175.500.000
4	Floor Concrete Work 2	Rp 46.060.000	Rp 246.750.000
5	Floor Concrete Work 3	Rp 36.855.000	Rp 197.437.500
6	1st Floor Sill Work	Rp 14.525.000	Rp 77.812.500
7	1st Floor Work	Rp 99.715.000	Rp 534.187.500
8	1st Floor Painting Work	Rp 28.000.000	Rp 150.000.000
9	2nd Floor Sill Work	Rp 14.525.000	Rp 77.812.500
10	3rd Floor Roof & Ceiling Work	Rp 41.895.000	Rp 224.437.500
11	3rd Floor Painting Work	Rp 28.000.000	Rp 150.000.000
12	2nd Floor Sanitation Work	Rp 15.355.000	Rp 84.037.500
13	3rd Floor Sanitation Works	Rp 15.355.000	Rp 84.037.500
14	1st Floor Electrical Installation Work	Rp 27.000.000	Rp 148.500.000
15	2nd Floor Electrical Installation Work	Rp 22.765.000	Rp 123.637.500
16	3rd Floor Electrical Installation Work	Rp 27.000.000	Rp 148.500.000
17	Other Jobs	Rp 9.225.000	Rp 50.737.500
18	Install Concrete Panel Fence	Rp 22.500.000	Rp 123.750.000
Total		Rp 569.100.000	Rp 3.066.675.000

The cost slope for the alternative of 4 hours of overtime according to [8] uses the formula

Cost slope = .. $\frac{\text{crash cost} - \text{normal cost}}{\text{durasi normal} - \text{durasi crash}}$ (24)

Table 5. Recapitulation of Alternative 4 Hour Overtime Cost Slope Using Project AHSP

No	Work	Cost slope
1	Preparatory Work	Rp 3.115.087,60
2	Excavation Of Soil, Fill & Foundation Floor 1	Rp 22.440.362,91
3	Concrete Structure & Foundation Work 1st Floor	Rp 8.870.008,31
4	Floor Concrete Work 2	Rp 14.252.662,93
5	Floor Concrete Work 3	Rp 8.870.008,31
6	1st Floor Sill Work	Rp 6.292.399,06
7	1st Floor Work	Rp 30.855.499
8	1st Floor Painting Work	Rp 12.129.925,90
9	2nd Floor Sill Work	Rp 6.292.399,06
10	3rd Floor Roof & Ceiling Work	Rp 12.963.858,30
11	3rd Floor Painting Work	Rp 12.129.925,90
12	2nd Floor Sanitation Work	Rp 6.459.675,95
13	3rd Floor Sanitation Works	Rp 6.459.675,95
14	1st Floor Electrical Installation Work	Rp 9.395.721,29
15	2nd Floor Electrical Installation Work	Rp 12.104.340,94
16	3rd Floor Electrical Installation Work	Rp 9.395.721,29
17	Other Jobs	Rp 3.210.204,77
18	Install Concrete Panel Fence	Rp 7.829.767,74
Total		Rp 193.067.245,23

E. Accelerating Crashing Using Alternative Shift Work

1. Productivity of Morning And Evening Work Shifts According to [6]

- Morning shift productivity = $\frac{\text{Volume}}{\text{normal duration}}$ (25)
- Night shift productivity = $(100\% - \text{Productivity Decline}) \times \text{Morning shift Productivity}$ (26)
- Total productivity per day = $\text{Morning productivity} + \text{Evening Productivity}$ (27)

2. Work Shift Alternate Crash Duration

- Crash shift duration [6]
- = $\frac{\text{Volume}}{\text{total productivity per day}}$ (28)

Table 6. Summary of Alternative Crash Duration of Work Shifts

No	Work	Normal Duration	Crash Duration
1	Preparatory Work	225	125
2	Excavation Of Soil, Fill & Foundation Floor 1	28	16
3	Concrete Structure & Foundation Work 1st Floor	56	31
4	Floor Concrete Work 2	49	28
5	Floor Concrete Work 3	63	35
6	1st Floor Sill Work	35	20
7	1st Floor Work	49	28
8	1st Floor Painting Work	35	20
9	2nd Floor Sill Work	35	20
10	3rd Floor Roof & Ceiling Work	49	28
11	3rd Floor Painting Work	35	20
12	2nd Floor Sanitation Work	37	21
13	3rd Floor Sanitation Works	37	21
14	1st Floor Electrical Installation Work	45	25
15	2nd Floor Electrical Installation Work	29	17
16	3rd Floor Electrical Installation Work	45	25
17	Other Jobs	45	25
18	Install Concrete Panel Fence	45	25
Total		942	530



3. Alternative Crash Costs of Work Shifts According to [8]

- Morning shift wages
= *normal day wages*..... (29)
- Night shift wages = *wages/day + (wages/day x 15%)*..... (30)

[8] uses the formula

$$\text{Cost slope} = \frac{\text{crash cost} - \text{normal cost}}{\text{durasi normal} - \text{durasi crash}} \dots\dots\dots (24)$$

Table 8. Alternative Crash Cost Shift Work Using AHSP Project

No	Work	Cost slope
1	Preparatory Work	Rp 530.437,50
2	Excavation Of Soil, Fill & Foundation Floor 1	Rp 3.971.333,33
3	Concrete Structure & Foundation Work 1st Floor	Rp 1.506.960
4	Floor Concrete Work 2	Rp 2.522.333,33
5	Floor Concrete Work 3	Rp 1.513.687,50
6	1st Floor Sill Work	Rp 1.113.583,33
7	1st Floor Work	Rp 5.460.583,33
8	1st Floor Painting Work	Rp 2.146.666,67
9	2nd Floor Sill Work	Rp 1.113.583,33
10	3rd Floor Roof & Ceiling Work	Rp 2.294.250
11	3rd Floor Painting Work	Rp 2.146.666,67
12	2nd Floor Sanitation Work	Rp 1.103.640,63
13	3rd Floor Sanitation Works	Rp 1.103.640,63
14	1st Floor Electrical Installation Work	Rp 1.552.500
15	2nd Floor Electrical Installation Work	Rp 2.181.645,83
16	3rd Floor Electrical Installation Work	Rp 1.552.500
17	Other Jobs	Rp 530.437,50
18	Install Concrete Panel Fence	Rp 1.293.750
Total		Rp 33.638.199,58

G. Comparison Results of the Application of the Crashing Method with Alternatives for the Addition of 4 Hours of Overtime and Work Shifts

- Total labor wages
= (*morning shift wages + night shift wages*) x *duration of work x number of workers*..... (31)

Table 7. Alternative Crash Cost Shift Work Using AHSP Project

No	Work	Normal Cost	Crash Cost
1	Preparatory Work	Rp 46.125.000	Rp 99.168.750
2	Excavation Of Soil, Fill & Foundation Floor 1	Rp 41.440.000	Rp 89.096.000
3	Concrete Structure & Foundation Work 1st Floor	Rp 32.760.000	Rp 70.434.000
4	Floor Concrete Work 2	Rp 46.060.000	Rp 99.029.000
5	Floor Concrete Work 3	Rp 36.855.000	Rp 79.238.250
6	1st Floor Sill Work	Rp 14.525.000	Rp 31.228.750
7	1st Floor Work	Rp 99.715.000	Rp 214.387.250
8	1st Floor Painting Work	Rp 28.000.000	Rp 60.200.000
9	2nd Floor Sill Work	Rp 14.525.000	Rp 31.228.750
10	3rd Floor Roof & Ceiling Work	Rp 41.895.000	Rp 90.074.250
11	3rd Floor Painting Work	Rp 28.000.000	Rp 60.200.000
12	2nd Floor Sanitation Work	Rp 15.355.000	Rp 33.013.250
13	3rd Floor Sanitation Works	Rp 15.355.000	Rp 33.013.250
14	1st Floor Electrical Installation Work	Rp 27.000.000	Rp 58.050.000
15	2nd Floor Electrical Installation Work	Rp 22.765.000	Rp 48.944.750
16	3rd Floor Electrical Installation Work	Rp 27.000.000	Rp 58.050.000
17	Other Jobs	Rp 9.225.000	Rp 19.833.750
18	Install Concrete Panel Fence	Rp 22.500.000	Rp 48.375.000
Total		Rp 569.100.000	Rp 1.223.565.000



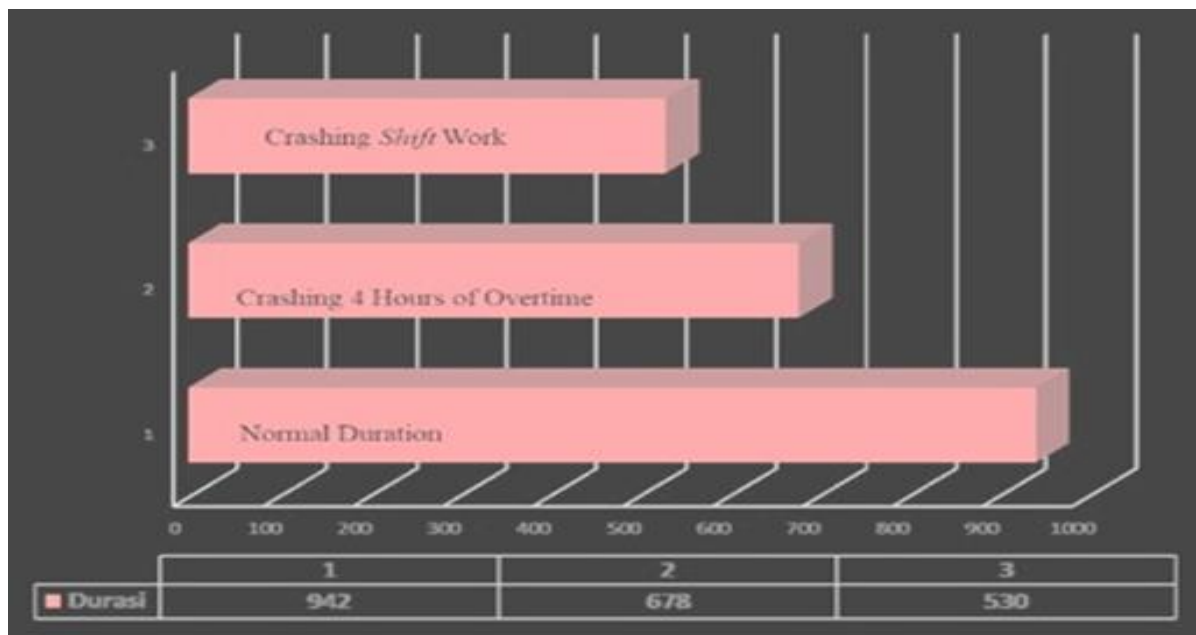


Figure 2. Bar Comparison of Normal Duration, Alternative 4 Hours of Overtime Work & Work Shifts

Based on Figure 2 which shows the normal duration and duration after acceleration using the crashing method with the addition of 4 hours of overtime work and work shifts. The normal duration is 942 days for 18 jobs that are late, then the additional alternative with 4 hours of overtime work, the resulting crash duration is 678 days, the difference is 264 days, then the difference in percentage is 28% of the normal duration and the alternative work shift is 530 days, the difference is i.e. 412 days ago the difference in percentage was 44%. Then the alternative of 4 hours of overtime is delayed compared to the accelerated work shift. However, this 4 hours of overtime work cannot be applied to alternatives that will be used in accelerated conditions for the PPLP Banten project. So the alternative duration of work shifts can be applied to alternatives that will be used in accelerated conditions for the Banten PPLP project because it is more efficient. Next is a picture of a comparison of the cost slope for the alternative 4 hours of overtime work and shift work using the AHSP project, which is as follows.

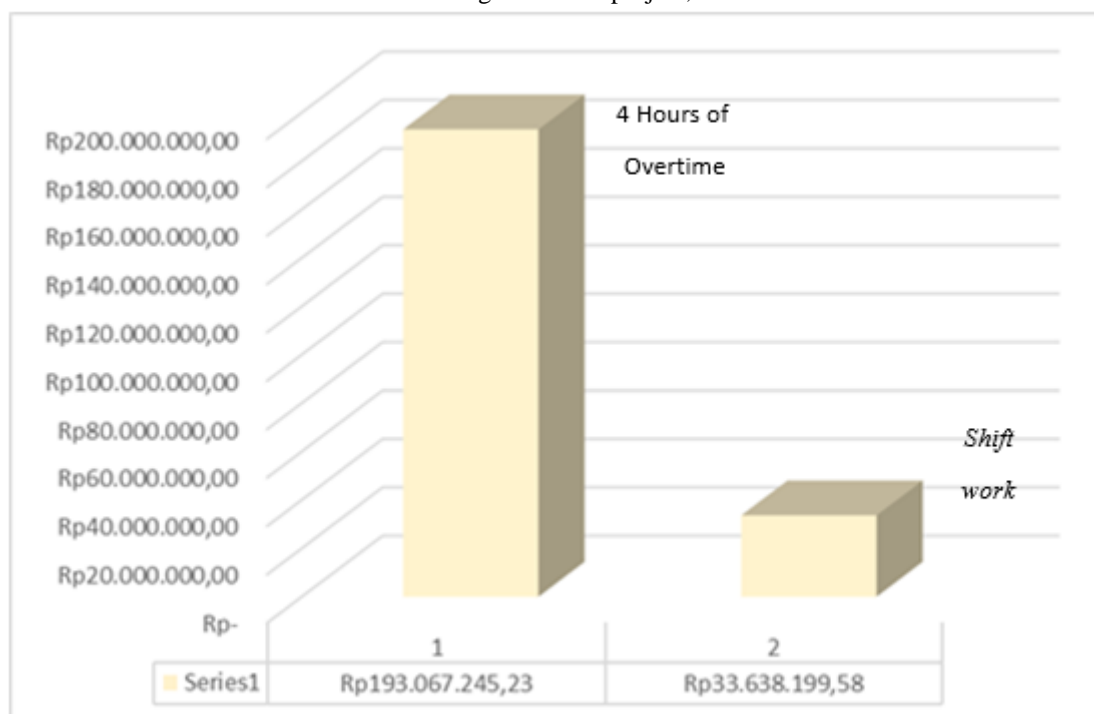


Figure 3. Cost Slope Comparison Column on 4 Hour Overtime Alternatives and Working Shifts Using Project AHSP

Based on Figure 3. it is explained that the cost slope (additional costs) using the AHSP project resulted in an alternative 4 hours of overtime worth Rp. 193,067,245.23 and an alternative to the work shift system Rp. 33,638,199.58 using the AHSP project.

H. Analysis of Direct Costs and Indirect Costs

1. Comparison of Direct Costs and Indirect Costs [1]

$$\text{Material Coefficient} = \frac{\text{Material Cost}}{\text{Wage and Material Cost}} \dots\dots\dots (25)$$

$$\text{Wage Coefficient} = \frac{\text{Wage Cost}}{\text{Material Cost and wage}} \dots\dots\dots (26)$$

$$\text{Direct cost weight} = \frac{\text{Material and labor costs}}{\text{HSP value}} \dots\dots\dots (27)$$

$$\text{Indirect cost weight} = 100\% - \text{direct cost weight} \dots\dots (28)$$

$$[8] \text{ Profit} = \text{Total project cost} \times 10\% \dots\dots\dots (29)$$

$$\text{Overhead cost} = \text{Total project cost} \times 3\% \dots\dots\dots (30)$$

$$\text{Overhead per day} = \frac{\text{Overhead Cost}}{\text{Normal Duration}} \dots\dots\dots (31)$$

$$\text{Direct cost} = \text{Total direct cost weight} \times \text{Total project cost} \dots\dots (32)$$

$$\text{Indirect cost} = \text{Profit} + \text{Overhead costs} \dots\dots\dots (33)$$

$$\text{Total costs} = \text{Direct costs} + \text{Indirect costs} \dots\dots\dots (34)$$

$$\text{Material cost} = \text{Direct cost} \times \text{material coefficient} \dots\dots (34)$$

$$\text{Cost of wages} = \text{Direct cost} \times \text{coefficient of wages} \dots\dots (35)$$

a) Direct costs

-Crashing alternative 4 hours of overtime work
= normal cost + total cost slope of 4 hours overtime (36)

Crashing alternative work shifts
= normal direct costs + total alternative shift cost slope (37)

b) Indirect costs

-Crashing alternative 4 hours of overtime work
= Crashing duration x overhead per day + profit (38)

-Crashing alternative work shifts
= Crashing duration x overhead per day + profit (39)

c) Total project cost after crashing

-Crashing alternative 4 hours of overtime work
= direct costs + indirect costs (40)

-Crashing alternative work shifts
= direct costs + indirect costs (41)

2. Comparison of Project Costs Using AHSP Projects

Table 9. Comparison of Duration and Cost Using AHSP Projects

	Duration	Direct Cost	Indirect Cost	Amount
Normal Condition Project	942	Rp 9.479.093.787	Rp 1.416.416.313	Rp 10.895.510.100
Crashing 4 Hours of Overtime	678	Rp 9.672.161.032,23	Rp 1.322.728.805.77	Rp 10.994.889.838
Crashing Shift Work	530	Rp 9.512.731.986,58	Rp 1.273.456.116,78	Rp 10.786.188.103,37

Based on table 9, it is obtained under normal project conditions, namely Rp.10,895,510,100 with a normal duration of 942 days according to the contract. If you use the accelerated alternative of 4 hours of overtime, you get Rp.10,994,889,838, you will experience swelling of Rp.99,379,738 or 0.91%, but the duration of 4 hours of overtime will be faster, namely 264 days or 28% of the normal duration and whereas if you use acceleration an alternative work shift obtained Rp.10,786,188,103.37 resulting in cost savings of Rp.109,321,996.63 or 1% with a shorter duration of 412 days or 44% from normal conditions. Can prove that the comparison of the results of calculating direct costs and indirect costs after crashing with the results of alternative calculations of 4 hours of overtime work with direct costs of Rp.9,672,161,032.23 and indirect costs of Rp.1,322,728,805.77 and alternative work shifts with costs direct costs of Rp.9,512,731,986.58 and indirect costs of Rp.1,273,456,116.78 which produce the minimum and can be applied to the Banten PPLP project are alternative work shifts. Because the work shift alternative is a better alternative which has the most economical additional cost results and can be applied to the Banten PPLP project compared to the 4hour overtime alternative.

IV. CONCLUSION

1. In jobs that experience delays, there are 18 jobs out of 43 jobs. Then the work that experienced delays included preparatory work, excavation work, fill & foundation 1st floor, concrete structure & foundation 1st floor, concrete work 2nd floor, concrete work lt. 3, sill work lt.1, floor work lt.1, painting work lt.1, sill work lt.2, roof & ceiling work lt.3, painting work lt.3, sanitation work lt.2, sanitation work lt. 3, electrical installation work on the 1st floor, electrical installation work on the 2nd floor, electrical installation work on the 3rd floor, other work and installation of concrete panel fences.
2. The total normal duration and cost of 18 jobs that are on the critical path with a normal duration of 942 days is Rp.569,100,000 using AHSP, the total duration of alternative crashing is 4 hours of overtime work, which is 678 days, while in the work shift, the total crash duration is 530 days . In the AHSP project, the resulting total alternative crash cost of 4 hours of overtime is Rp.3,066,675,000 and a work shift with a crash cost of Rp.1,223,565,000.
3. The results of the cost slope comparison using the AHSP project are the calculation of the additional cost of 4 hours of overtime using the AHSP project of Rp.193,067,245.23 for the additional cost of work shift using the AHSP project of Rp.33,638,199.58.
4. The results of direct and indirect costs are alternative results of 4 hours of overtime work, direct costs of Rp.9,672,161,032.23 and indirect costs of Rp.1,322,728,805.77 whereas when using accelerated work shifts, direct costs are Rp.9,512,731,986. 58 and indirect costs of Rp.1,273,456,116.78. So the alternative acceleration of work shifts at direct and indirect costs is more economical and was chosen to be applied to the PPLP-Banten building project.

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