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# Acceleration Cost Analysis with Critical Path Method

# (Case Study on Jakarta Sewerage Development Project Zone 1, Package 2: Construction of Wastewater Sewers in Area 1-1)

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ABSTRACT

In a construction project, preparation work typically includes tasks related to setting up work facilities, conducting field investigations, obtaining permits, and non-structural activities. The Jakarta Sewerage Development Project Zone 1, Package 2, which involves the construction of sewers in Area 1-1, is currently in the preparation phase and is experiencing challenges due to a complex permit process. This has led to minimal progress as the initial project planning did not consider the time needed to secure the necessary permits for implementation. The author is therefore evaluating the project timeline to gauge performance during the preparation phase before actual construction begins. This study utilizes the Critical Path Method (CPM) scheduling technique in Microsoft Project to pinpoint critical activities. Upon analysis, it was found that the budget plan for Package 2 of the Jakarta Sewerage Development Project (Zone 1) was detailed and included various work descriptions, with a total budget of IDR 862,292,086,196. However, delays have occurred, resulting in a 17-day setback in the project schedule, necessitating work acceleration. To bring the project duration back in line with the original schedule as per the contract, acceleration was required. This was carried out on the Shaft Construction C-8.1, which was initially set to take 80 days but was shortened to 63 days through time acceleration, incurring a cost of IDR 23,279,288.

Keywords: Construction Project, Preparation Work, Permit Process, Critical Path (CPM), Cost

## 1. Introduction

A project can be defined as an organized effort to achieve important goals, objectives, and expectations using the available budget and resources, which must be completed within a specified period (Dipohusodo, 1996). As human civilization advances, the scale and complexity of projects increase, involving more sophisticated materials, labor, and technology (Heizer, 2015). Projects typically have deadlines, meaning they must be completed on or before a predetermined time. Therefore, the successful execution of a project on time is crucial for both the project owner and the contractor (Ervianto & Felasari, 2019). Successful project implementation requires supporting aspects, such as reliable human resources and good management, to ensure the project is completed within the specified time (Herjanto, 2007).

The process of planning and controlling the project during construction is an essential activity . Planning is a process that lays the groundwork for goals and objectives, including preparing all necessary resources to achieve them (Masqur, 2020). It provides guidance for resource allocation to carry out activities (Soeharto, 1997). Effective cost management is needed to regulate incoming and outgoing budgets, ensuring the project proceeds without delays or financial deficits (Soeharto, 1999). The success or failure of a project is often due to inadequate planning and ineffective control, leading to inefficiency, delays, reduced work quality, and increased costs. Delays in project completion are highly undesirable because they can financially harm both parties.

In this study, a brief overview of the project is as follows: the client is the PPK Sanitasi I, the Working Unit for Housing Infrastructure Development of the Jakarta Metropolitan Area, under the Directorate General of Human Settlements, Ministry of Public Works and Housing. The supervising consultant is a joint venture (OCMY JO) consisting of Oriental Consultants Global, CTI Engineering International, PT Multi Karadiguna Jasa, and PT Yodya Karya. The contractor is a joint venture (KG-WIKA-JAKON JV) of Kumagai Gumi Co., Ltd., PT. Wijaya Karya (Persero) Tbk., and PT. Jaya Konstruksi Manggala Pratama Tbk. The project is located in Central Jakarta, on Jl. Purworejo (Menteng) – Thamrin – Kebon Kacang – Tanah Abang – Jl. Abdul Muis – Cideng, with a project duration of 1460 days from November 14, 2023, to November 12, 2027, followed by a 365-day maintenance period.

Construction projects are generally divided into three phases: the planning phase, the execution phase, and the maintenance phase (Ritz & Levy, 1994). The execution phase can be further divided into three stages: preparation work, main structural work, and finishing work. The initial stage of a construction project is the preparation phase, which includes mobilizing resources, conducting investigations, building project facilities, and obtaining permits.

This project, located on an active public road, will affect the mobility of the surrounding community once activities commence; therefore, administrative processes involving permits for affected stakeholders must be accommodated. Planning project activities is essential to avoid delays, and methods like Network Planning have been developed to assist in planning complex work, such as constructing a sewer network (Rakasyiwi et al., 2022). Proper planning and scheduling are necessary to ensure the project is executed as efficiently and effectively as possible. Accelerating the project timeline through careful planning during the initial phase is crucial to prevent delays (Schwalbe, 2006). Various methods are available for scheduling with Network Planning. This study uses the Critical Path Method (CPM) scheduling technique, supported by Microsoft Project, to examine the Jakarta Sewerage Development Project, Package 2: Construction of Sewers in Area 1-1.

Through this cost analysis, the project's performance during the preparation phase can be assessed before the primary work begins. The evaluation results can serve as an early warning if inefficiencies arise during project completion, allowing for adjustments in execution methods, which may incur additional costs but help prevent delays. This study aims to analyze the costs associated with accelerating the work to ensure the Jakarta Sewerage Development Project Zone 1, Package 2: Construction of Sewers in Area 1-1 is completed on schedule.

## 2. Methodology

### 2.1. Flowchart of the Research

The research is illustrated with the following flowchart:

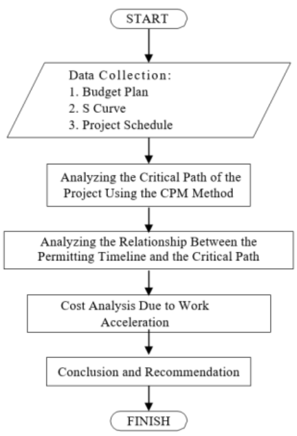


**Figure 1. Flowchart of the Research**

### 2.2. Data Collection

Data collection was conducted by the author at Kumagai Gumi – Wika – Jakon Joint Venture as the implementing contractor for the Jakarta Sewerage Development Project Zone 1, Package 2: Construction of Sewers in Area 1-1, as well as through literature studies related to the author's thesis. The data collected by the author is divided into two types: primary data and secondary data. Primary data was obtained directly from Kumagai Gumi – Wika – Jakon Joint Venture, while secondary data collected from the project includes the project's Budget Plan and other data relevant to the author's research.

## 3. Results and Discussion

### 3.1. Budget Plan

The following is the budget plan for the Jakarta Sewerage Development Project (Zone 1) Package 2: Construction of Sewers in Area 1-1.

**Table 1. Budget Plan**

| No. | Description of Work | Total Value IDR | Weight |
|---|---|---|---|
| 1 | Bill No.1 General Requirements | 133,862,890,556 | 15.52% |
| 2 | Bill No.2 Pipe Jacking Work | | |
| 2.1 | Bill No.2-1 Pipe Jacking Work | 408,061,927,270 | 47.32% |
| 2.2 | Bill No.2-2 Shaft Construction | 176,570,103,048 | 20.48% |
| 2.3 | Bill No.2-3 Manhole Construction | 18,653,574,959 | 2.16% |
| 2.4 | Bill No.2-4 Repavement | 27,922,454,994 | 3.24% |
| 2.5 | Bill No.2-5 Existing Plant | 4,478,652,107 | 0.52% |
| 3 | Bill No.3 Diversion Chamber | | |
| 3.1 | Bill No.3-1 Diversion Chamber | 24,558,039,232 | 2.85% |
| 3.2 | Bill No.3-2 Connecting Pipe | 1,755,916,232 | 0.20% |
| 3.3 | Bill No.3-3 Outlet Pipe | 4,785,399,872 | 0.55% |
| 3.4 | Bill No.3-4 Inflow Pit | 2,168,566,636 | 0.25% |
| 4 | Bill No.4 Persil Pipe Jacking Work | 7,236,119,376 | 0.84% |
| 5 | Total for Day work (Provisional Sum) | 733,950,000 | 0.09% |
| 6 | Specified Provisional Sums | 10,442,964,000 | 1.21% |
| 7 | Contingency Allowance (5%) | 41,061,527,914 | 4.76% |
| | **TOTAL** | **862,292,086,196** | **100.00%** |

Source: Project Data Kumagai Gumi – Wika – Jakon JV, 2023

### 3.2. Analysis of the Relationship Between the Permit Process and the Critical Path of the Project

From the analysis of the Master Schedule's critical path, it is noted that the target start date for the main work, specifically the Shaft construction, is set for June 3, 2024. However, the Master Schedule does not account for the duration of the entire permit process. Therefore, the author has linked the permit process to the critical path of this project .

At the time of this research, the project has already conducted test pit work and is still in the permit process for utility relocation. The calculation for the permit process for utility relocation until the start of the shaft work requires approximately 58 days. Consequently, the researcher has integrated this process into the critical path of the Master Schedule, just after the test pit work, starting on April 24, 2024. Below are the results from integrating the permit process into the critical path of this Master Schedule:

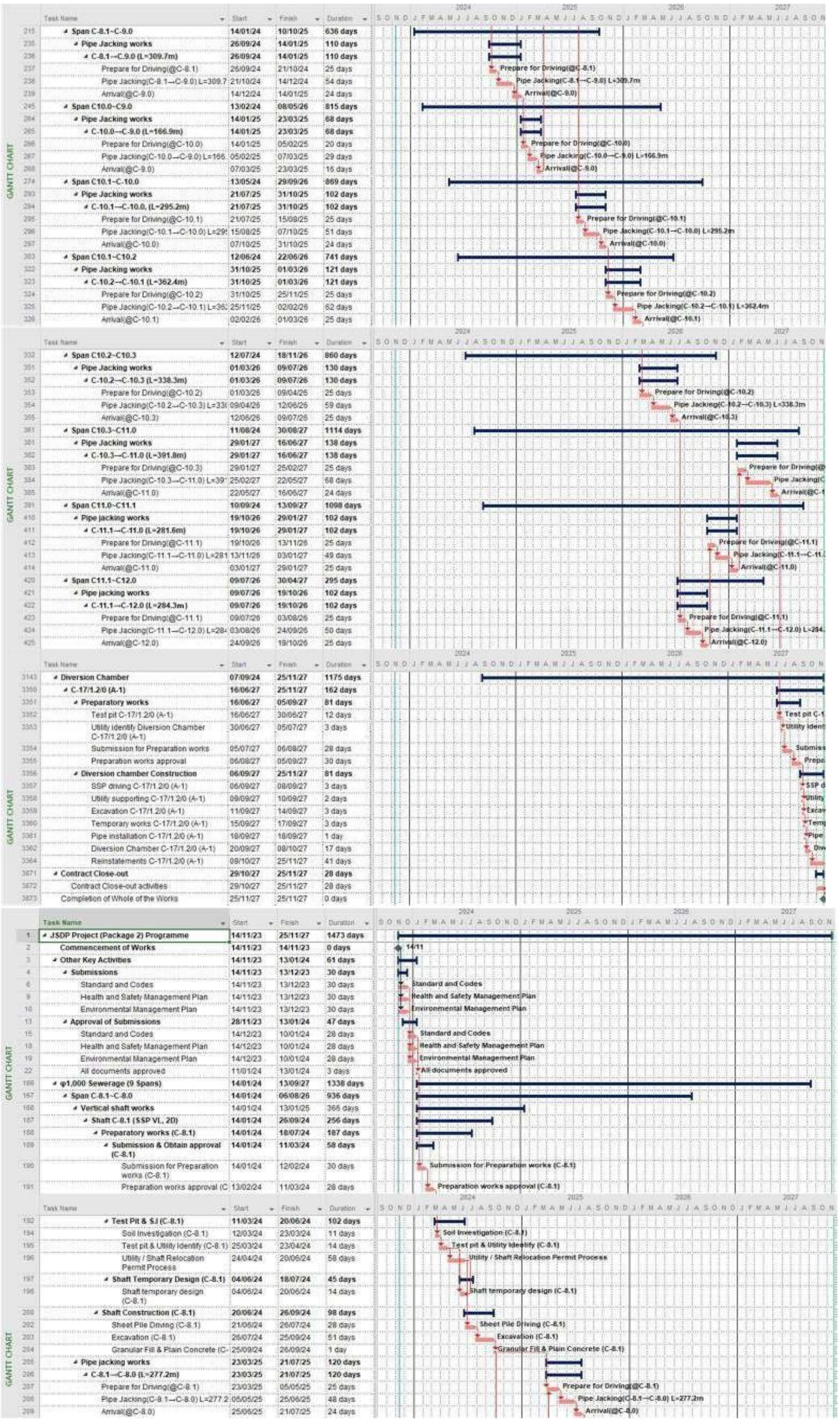

**Figure 2. Results of the Analysis of the Relationship Between the Permit Process and the Critical Path CPM in Microsoft Project**

Source: Processed Data by the Author, 2024

**Table 2. Report of the Analysis of the Relationship Between the Permit Process and the Critical Path CPM in Microsoft Project**

| ID | Name | Start | Finish | Duration | Predecessors |
|---|---|---|---|---|---|
| 2 | Commencement of Works | 14/11/23 | 14/11/23 | 0 days | |
| 6 | Standard and Codes | 14/11/23 | 13/12/23 | 30 days | 2 |
| 9 | Health and Safety Management Plan | 14/11/23 | 13/12/23 | 30 days | 2 |
| 10 | Environmental Management Plan | 14/11/23 | 13/12/23 | 30 days | 2 |
| 15 | Standard and Codes | 14/12/23 | 10/01/24 | 28 days | 6 |
| 18 | Health and Safety Management Plan | 14/12/23 | 10/01/24 | 28 days | 9 |
| 19 | Environmental Management Plan | 14/12/23 | 10/01/24 | 28 days | 10 |
| 22 | All documents approved | 11/01/24 | 13/01/24 | 3 days | 14;15;16;17;18;19;20;21 |
| 190 | Submission for Preparation works (C-8.1) | 14/01/24 | 12/02/24 | 30 days | 22 |
| 191 | Preparation works approval (C-8.1) | 13/02/24 | 11/03/24 | 28 days | 190 |
| 194 | Soil Investigation (C-8.1) | 12/03/24 | 23/03/24 | 11 days | 191 |
| 195 | Test pit & Utility Identify (C-8.1) | 25/03/24 | 23/04/24 | 14 days | 194 |
| 196 | Utility / Shaft Relocation Permit Process | 24/04/24 | 20/06/24 | 58 days | 195 |
| 198 | Shaft temporary design (C-8.1) | 04/06/24 | 20/06/24 | 14 days | 195;196FF |
| 202 | Sheet Pile Driving (C-8.1) | 21/06/24 | 26/07/24 | 28 days | 198;196 |
| 203 | Excavation (C-8.1) | 26/07/24 | 25/09/24 | 51 days | 202 |
| 204 | Granular Fill & Plain Concrete (C-8.1) | 25/09/24 | 26/09/24 | 1 day | 203 |
| 207 | Prepare for Driving(@C-8.1) | 23/03/25 | 05/05/25 | 25 days | 268;204;185 |
| 208 | Pipe Jacking(C-8.1→C-8.0) L=277.2m | 05/05/25 | 25/06/25 | 48 days | 207 |
| 209 | Arrival(@C-8.0) | 25/06/25 | 21/07/25 | 24 days | 208 |
| 237 | Prepare for Driving(@C-8.1) | 26/09/24 | 21/10/24 | 25 days | 204;233 |
| 238 | Pipe Jacking(C-8.1→C-9.0) L=309.7m | 21/10/24 | 14/12/24 | 54 days | 237 |
| 239 | Arrival(@C-9.0) | 14/12/24 | 14/01/25 | 24 days | 238 |
| 266 | Prepare for Driving(@C-10.0) | 14/01/25 | 05/02/25 | 20 days | 239;263;233 |
| 267 | Pipe Jacking(C-10.0→C-9.0) L=166.9m | 05/02/25 | 07/03/25 | 29 days | 266 |
| 268 | Arrival(@C-9.0) | 07/03/25 | 23/03/25 | 16 days | 267 |
| 295 | Prepare for Driving(@C-10.1) | 21/07/25 | 15/08/25 | 25 days | 209;292;263 |
| 296 | Pipe Jacking(C-10.1→C-10.0) L=295.2m | 15/08/25 | 07/10/25 | 51 days | 295 |
| 297 | Arrival(@C-10.0) | 07/10/25 | 31/10/25 | 24 days | 296 |
| 324 | Prepare for Driving(@C-10.2) | 31/10/25 | 25/11/25 | 25 days | 297;321;292 |
| 325 | Pipe Jacking(C-10.2→C-10.1) L=362.4m | 25/11/25 | 02/02/26 | 62 days | 324 |
| 326 | Arrival(@C-10.1) | 02/02/26 | 01/03/26 | 25 days | 325 |
| 353 | Prepare for Driving(@C-10.2) | 01/03/26 | 09/04/26 | 25 days | 326;350;321 |
| 354 | Pipe Jacking(C-10.2→C-10.3) L=338.3m | 09/04/26 | 12/06/26 | 59 days | 353 |
| 355 | Arrival(@C-10.3) | 12/06/26 | 09/07/26 | 25 days | 354 |
| ID | Name | Start | Finish | Duration | Predecessors |
| 383 | Prepare for Driving(@C-10.3) | 29/01/27 | 25/02/27 | 25 days | 414;379;350 |
| 384 | Pipe Jacking(C-10.3→C-11.0) L=391.8m | 25/02/27 | 22/05/27 | 68 days | 383 |
| 385 | Arrival(@C-11.0) | 22/05/27 | 16/06/27 | 24 days | 384 |
| 412 | Prepare for Driving(@C-11.1) | 19/10/26 | 13/11/26 | 25 days | 425;409;47 |
| 413 | Pipe Jacking(C-11.1→C-11.0) L=281.6m | 13/11/26 | 03/01/27 | 49 days | 412 |
| 414 | Arrival(@C-11.0) | 03/01/27 | 29/01/27 | 25 days | 413 |
| 423 | Prepare for Driving(@C-11.1) | 09/07/26 | 03/08/26 | 25 days | 355;379;409 |
| 424 | Pipe Jacking(C-11.1→C-12.0) L=284.3m | 03/08/26 | 24/09/26 | 50 days | 423 |
| 425 | Arrival(@C-12.0) | 24/09/26 | 19/10/26 | 25 days | 424 |
| 3352 | Test pit C-17/1.2/0 (A-1) | 16/06/27 | 30/06/27 | 12 days | 385 |
| 3353 | Utility identify Diversion Chamber C-17/1.2/0 (A-1) | 30/06/27 | 05/07/27 | 3 days | 3352 |
| 3354 | Submission for Preparation works | 05/07/27 | 06/08/27 | 28 days | 3353 |
| 3355 | Preparation works approval | 06/08/27 | 05/09/27 | 30 days | 3354 |
| 3357 | SSP driving C-17/1.2/0 (A-1) | 06/09/27 | 08/09/27 | 3 days | 3355 |
| 3358 | Utility supporting C-17/1.2/0 (A-1) | 09/09/27 | 10/09/27 | 2 days | 3357 |
| 3359 | Excavation C-17/1.2/0 (A-1) | 11/09/27 | 14/09/27 | 3 days | 3358 |
| 3360 | Temporary works C-17/1.2/0 (A-1) | 15/09/27 | 17/09/27 | 3 days | 3359 |
| 3361 | Pipe installation C-17/1.2/0 (A-1) | 18/09/27 | 18/09/27 | 1 day | 3360 |
| 3362 | Diversion Chamber C-17/1.2/0 (A-1) | 20/09/27 | 08/10/27 | 17 days | 3361 |
| 3364 | Reinstatements C-17/1.2/0 (A-1) | 09/10/27 | 25/11/27 | 41 days | 3362 |
| 3872 | Contract Close-out activities | 29/10/27 | 25/11/27 | 28 days | 388;1229;1217;1831;2583;3100;3364FF |
| 3873 | Completion of Whole of the Works | 25/11/27 | 25/11/27 | 0 days | 3872;390;478;1231;3171;3392;3751;506;1833;3364;3525 |

Source: Processed Data by the Author, 2024

From Table 2, the Flowchart of the Permit Process for Preparation Work, and Table 4.4, the Critical Path Report in Microsoft Project, it is shown that the integration of the permit process into the Master Schedule's Critical Path has caused the start date of the Shaft work to shift from June 3, 2024, to June 21, 2024, resulting in a delay of 17 days.

### 3.3. Cost Analysis Due to Work Acceleration (Crashing)

To accelerate the timeline, commonly referred to as a crash program, the following assumptions are made: a) The availability of resources is not a constraint. B) If a quicker completion time is desired while maintaining the same scope, resources will increase, whether in the form of labor, materials, equipment, or other equivalent means. The primary goal of the crashing program is to shorten the project schedule with minimal cost increase.

The crashing program or acceleration of activity completion is based on direct costs, specifically direct labor costs. By shortening the timeline, there is an observed increase in direct labor rates due to additional work hours incurred from overtime. Normal working hours are from 08:00 to 12:00 and then from 13:00 to 17:00. Break times are not included, making the normal working hours total 8 hours.

In this context, the standard overtime wage rates are: a) If the overtime work is less than 6 hours, the rate charged is the overtime hours multiplied by the standard hourly wage. b) If the overtime equals 6 hours, the overtime rate charged is double the standard daily wage. The project cost is analyzed by implementing time acceleration on several project activities through additional working hours or overtime. These activities fall on the critical path, necessitating acceleration to prevent delays in project completion.

After analyzing the project timeline by connecting the duration of the utility relocation permit process with the project's critical path, it is concluded that the schedule for the main Shaft work at location C-8.1 will be delayed by 17 days, moving the start date from June 3, 2024, to June 21, 2024. To realign the project duration with the planned contract schedule, acceleration is needed. This acceleration is applied to the Shaft Construction C-8.1, which was originally planned for 80 days but is now expedited by 17 days to 63 days. Consequently, the cost of this acceleration due to the addition of work hours/overtime is calculated using the unit price analysis data obtained from the project as follows:

JAKARTA SEWERAGE DEVELOPMENT PROJECT (ZONE-1)
ICB CIVIL WORKS (PACKAGE 2) CONSTRUCTION OF SEWERS IN AREA 1-1
UNIT RATE ANALYSIS

NAME : No.12 Vertical Shaft
UNIT : Nos
NUMBER OF PAY ITEM : 2.2.12
QUANTITY : 2

| NO. | DESCRIPTION | UNIT | COEFISIEN | UNIT PRICE ( IDR ) | AMOUNT |
|---|---|---|---|---|---|
| A | Labour | | | | |
| | Foreman | m.days | 42.00 | 235,000 | 9,870,000 |
| | Skilled Worker | m.days | 84.00 | 190,000 | 15,960,000 |
| | Worker | m.days | 420.00 | 155,000 | 65,100,000 |
| | Operator | m.days | 33.00 | 235,000 | 7,755,000 |
| | | | | SUB TOTAL | 98,685,000.00 |
| B. | Materials | | | | |
| | Provide Type IV Sheet pile | Ton | 13.10 | 21,000,000 | 275,138,639 |
| | Provide Type IV Corner sheet pile | Ton | 3.13 | 21,000,000 | 65,673,720 |
| | Provide Type IV Sheet pile (temporary) | Ton | 32.71 | 15,250,000 | 498,809,036 |
| | Provide Type IV Corner sheet pile (temporary) | Ton | 3.13 | 15,250,000 | 47,691,630 |
| | Provide Road Deck (temporary) | m2 | 36.00 | 3,150,000 | 113,400,000 |
| | Shoring work H-300 x 300 x 10 x 15 (temporary) | Ton | 4.06 | 16,700,000 | 67,802,000 |
| | Shoring work H-350 x 350 x 12 x 19 (temporary) | Ton | 2.32 | 16,700,000 | 38,744,000 |
| | Shoring work H-400 x 400 x 13 x 21 (temporary) | Ton | 5.27 | 16,700,000 | 88,050,750 |
| | Support Beam & Road deck system (temporary) | Ton | 3.85 | 16,700,000 | 64,295,000 |
| | Gravel | m3 | 3.93 | 305,000 | 1,197,430 |
| | Readymix Concrete fc18 Mpa | m3 | 3.62 | 1,314,000 | 4,761,936 |
| | Buis beton dia. 100cm H=50cm | Pcs | 3.00 | 330,000 | 990,000 |
| | Superjet thickness 1,5mm | m3 | 14.50 | 13,000,000 | 188,500,000 |
| | Fuel | Lt | 9,542.06 | 13,400 | 127,863,604 |
| | | | | SUB TOTAL | 1,582,917,745.66 |
| C. | Machinery | | | | |
| | Vibro Hammer PC 200 | Hours | 79.67 | 450,000 | 35,851,500 |
| | Vibro Hammer PC 400 (for remove sheet pile) | Hours | 170.65 | 600,000 | 102,390,000 |
| | Excavator PC 200 | Hours | 1.87 | 450,000 | 841,500 |
| | Excavator PC 200 Long arm | Hours | 3.12 | 600,000 | 1,872,000 |
| | Crawler Crane + Bucket Clampshell | Hours | 59.04 | 1,250,000 | 73,800,000 |
| | Dump Truck 3.5 ton | Hours | 67.81 | 200,000 | 13,562,000 |
| | Excavator + Breaker | Hours | 18.57 | 690,000 | 12,813,300 |
| | Crane 25T | Hours | 33.00 | 637,500 | 21,037,500 |
| | Hand Stamper | Hours | 1.47 | 100,000 | 147,000 |
| | Tools | Ls | 1.00 | 5,000,000 | 5,000,000 |
| | | | | SUB TOTAL | 267,314,800.00 |
| D | TOTAL CONSTRUCTION COST ( D=A+B+C ) | | | | 1,948,917,545.66 |
| E | OVERHEAD & PROFIT | 10% | x D | | 194,891,754.57 |
| F | RATE ( D + E ) | | | | 2,143,809,300.23 |
| | ROUNDED TOTAL | | | | 2,143,809,300.00 |

**Figure 3. Unit Price Analysis for Shaft Work C-8.1**
Source: Kumagai Gumi – WIKA – JAKON JV Project Data, 2023

Based on the unit price analysis data, the list of worker wages per hour is calculated and displayed in the following table:

**Table 3. Basic Hourly Wage Rates**

| No. | Description | Unit | Daily Wage (IDR) | Hourly Wage (IDR) |
|---|---|---|---|---|
| 1 | Foreman | OH | 235,000 | 29,375 |
| 2 | Skilled Labor | OH | 190,000 | 23,750 |
| 3 | Worker | OH | 155,000 | 19,375 |
| 4 | Operator | OH | 235,000 | 29,375 |

Source: Data Processed by Author, 2024

Cost Calculation for the Jakarta Sewerage Development Project (Zone 1) Package 2: Construction of Sewers in Area 1-1:

a. Shaft Work C-8.1:

| | |
|---|---|
| Work Weight Calculation | = 2,143,809,300/862,292,086,196 = 0.0025 |
| Normal Duration | = 80 days |
| Accelerated Duration | = 17 days |
| Post-Acceleration Duration | = 80 – 17 = 63 days |
| Normal Work Weight per Day | = 0.0025 / 80 = 0.000031 |
| Accelerated Work Weight per Day | = 0.0025 / 63 = 0.000039 |
| Additional Overtime | = ( (0.000039 - 0.000031) / 0.000031) x 8 = 2,06 hours |

b. Overtime Wages Calculation:

| | |
|---|---|
| Foreman | = 1 x 2,06 x 63 x Rp 29,375 = Rp. 3,812,288 |
| Skilled Labor | = 1 x 2,06 x 63 x Rp 23,750 = Rp. 3,082,275 |
| Workers | = 5 x 2,06 x 63 x Rp 19,375 = Rp. 12,572,438 |
| Operator | = 1 x 2,06 x 63 x Rp 29,375 = Rp. 3,812,288 |
| Total Overtime Cost | = Rp. 23,279,288 |

The result of the cost analysis due to the acceleration of time with the addition of working hours/overtime to expedite the Shaft C-8.1 work from the original 80 days to 63 days is IDR 23,279,288.

## 4. Conclusion

From the cost analysis resulting from the time acceleration through added working hours/overtime to expedite the Shaft C-8.1 work from the original 80 days to 63 days, the total cost is IDR 23,279,288. To analyze time and costs in a project, the Critical Path Method can be employed to identify delays and calculate expenses related to acceleration efforts, ensuring that the project's execution aligns with the contractual timeline.

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