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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)

Ade Sholeh Hartawan[1], Budi Witjaksana[2], Esti Wulandari[3]*

[1-3]Master of Civil Engineering Study Program, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya, Indonesia

E-mail: [1)] sholeh3107@gmail.com, [2)] budiwitjaksana@untag-sby.ac.id, [3)] wulandariesti@untag- sby.ac.id

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*Coresponding author:
Ade Sholeh Hartawan
sholeh3107@gmail.com

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:

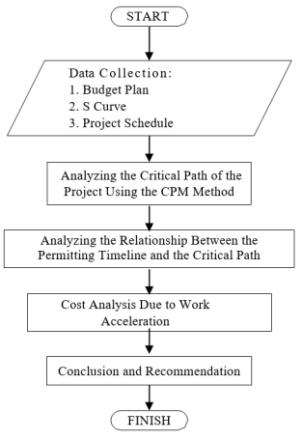

Figure 1. Flowchart of the Research

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:

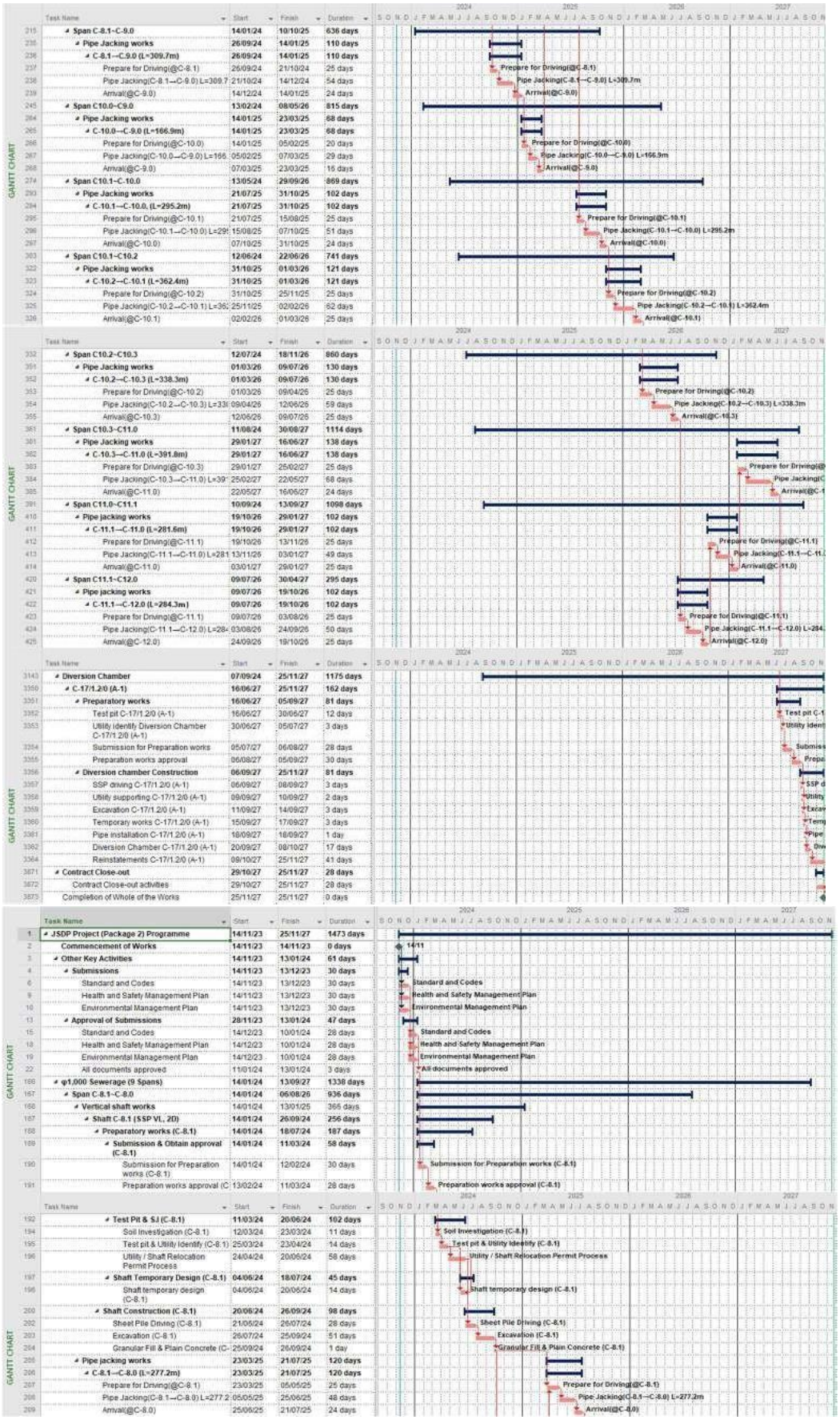

Figure 2. Results of the Analysis of the Relationship Between the Permit Process and the Critical Path CPM in Microsoft Project

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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