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COMPARATIVE ANALYSIS OF ACCELERATION ALTERNATIVES FOR THE DRAINAGE CHANNEL PROJECT ON XYZ STREET USINGTHE TIME-COST TRADE-OFF (TCTO) METHOD

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Abstract

In response to the increasing occurrence of rain, the city government is actively striving to mitigate urban flooding by enhancing the drainage system. Collaboration with contracted construction firms is central to this endeavor, although it is not without its challenges, including community opposition driven by concerns over potential disruptions and limited financial resources among contractors. This study adopts the Critical Path Method (CPM) and Microsoft Project software, supplemented with the Time Cost Trade Off (TCTO) method to expedite project completion, emphasizing a comprehensive evaluation that encompasses both time and financial aspects. Notably, the analysis identifies the most feasible acceleration opportunity within the excavation of ordinary soil for construction, with original plans indicating a cost of Rp. 60,818,919 over a 40-day period. Three alternatives are considered: (1) overtime labor, incurring Rp. 65,520,000, with a 34-day duration; (2) increased workforce, incurring Rp. 68,000,000, with a 34-day duration; and (3) introducing a new addendum for the replacement of manual excavation with heavy machinery, incurring Rp. 37,440,000, with a 16-day duration. In conclusion, this study provides a comprehensive strategy for accelerating the urban drainage project, considering the critical path, time-cost trade-offs, and cost-benefit factors, highlighting the significance of selecting the most cost-effective alternative while addressing community concerns and resource limitations in flood risk mitigation efforts.

Keywords: *CPM, Ms. Project, TCTO*

1. INTRODUCTION

In the urban context, weather uncertainty, particularly in the form of frequent rainfall, has emerged as a persistent concern, precipitating significant flood risks. As a proactive measure in the endeavor to mitigate the impact of these floods, the municipal government has taken decisive actions. A central strategy in this endeavor is the establishment of an efficient drainage system, aimed at diminishing the city's vulnerability to flooding. This ambitious project is being executed through a strategic partnership with construction contractors possessing specialized expertise in this field. To ensure the completion of the drainage project prior to the Eid al-Fitr celebration, thereby enabling the city's residents to observe the festival safely and comfortably, stringent measures have been taken. However, regrettably, the project has encountered substantial challenges resulting in detrimental delays.

The timeliness of project delivery has emerged as a pressing issue necessitating resolution. The increasing variance between the actual project schedule and the originally planned timeline has presented substantial impediments impacting various project phases. In addressing these issues, the Time Cost Trade Off (TCTO) methodology has emerged as a pertinent and relevant solution. As articulated by Ervianto (2004), the TCTO concept embodies a systematic and analytical process that prioritizes the evaluation of all activities within a project, with a particular focus on those situated along the critical path. This approach places paramount emphasis on cost considerations in assessing various acceleration alternatives. Moreover, TCTO transcends the temporal dimension, enabling the municipal government to gain comprehensive insights into the financial implications associated with each alternative.

Following meticulous analysis, it becomes evident that expediting the excavation of ordinary soil for construction emerges as the most promising course of action. The initial cost estimate for this task is Rp. 60,818,919, with a projected duration of 40 days. However, a comprehensive evaluation of three alternatives has been undertaken. The first alternative involves the incorporation of overtime labor incurring an acceleration cost of Rp. 65,520,000, thereby reducing the duration to 34 days. The second alternative entails augmenting the workforce with an acceleration cost of Rp. 68,000,000, maintaining a 34-day duration. The third alternative introduces a new item, which replaces manual soil excavation with the utilization of heavy machinery, incurring an acceleration cost of Rp. 37,440,000, and significantly reducing the timeline to 16 days.

It is imperative to underscore that this evaluation encompasses not only the temporal dimension but also the financial aspects. The results of this analysis underscore the urgency of selecting the most cost-efficient alternative while vigilantly considering community concerns and the inherent resource constraints within the context of urban flood risk mitigation. Thus, the primary aim of this research is to provide a comprehensive perspective on how the Time Cost Trade Off (TCTO) method can be applied to address project delay issues within the vital urban infrastructure construction project, duly considering temporal and financial facets, alongside the community's needs in the realm of flood risk mitigation.

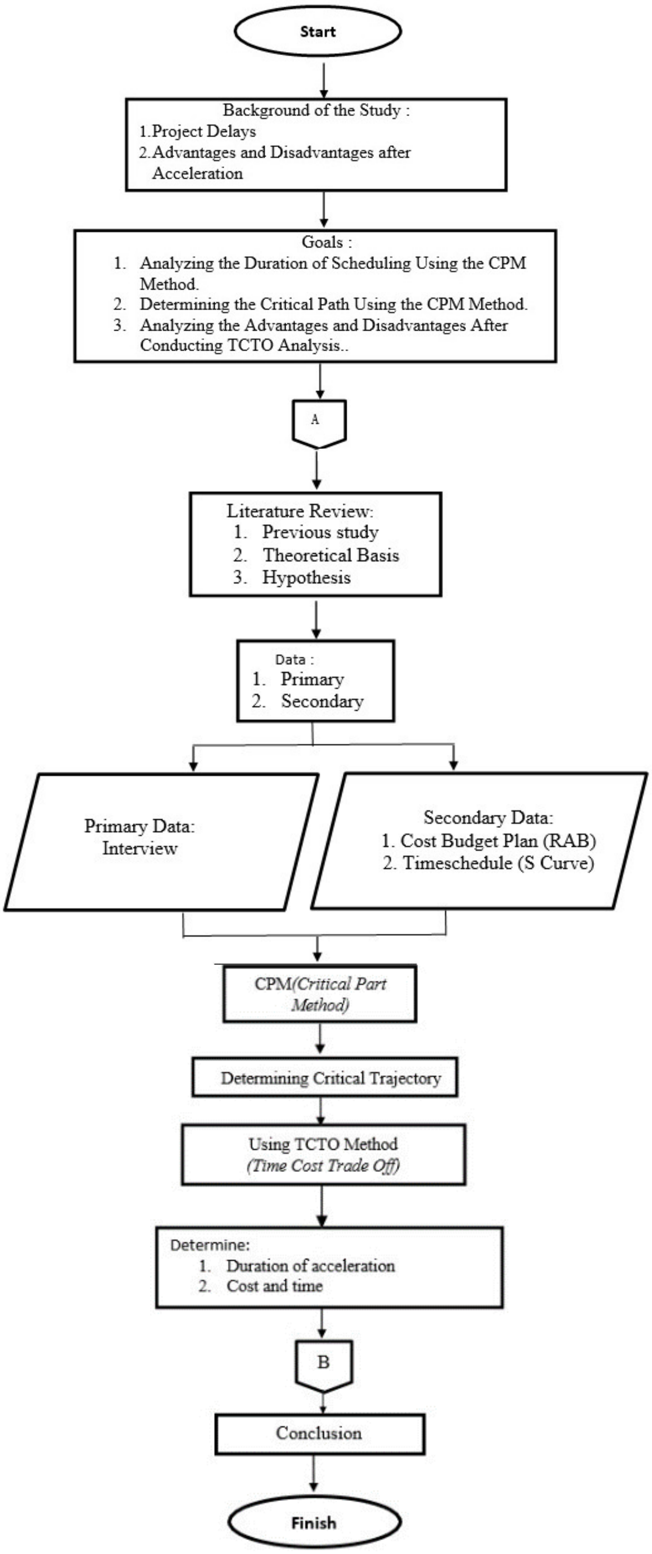
2. RESEARCH METHODS

2.1. Data Collection Procedure

In this research, data collection was conducted through direct observation using the following references:

a. Secondary The data collected consisted of secondary data, specifically the Budget Cost Plan (*Rencana Anggaran Biaya* - RAB) of the contract.
b. Existing time schedules or schedules submitted during the tender process were also collected.
c. Data collection was carried out over a period of one month.

This multifaceted data collection approach formed the basis for subsequent analyses, including critical path identification, financial assessments, and evaluation of acceleration measures.



Source: Processed data (2023)

Figure 1. Research Flowchart

2.2. Data Analysis Technique

2.2.1. Identification of the Critical Path

In the drainage project on XYZ Street in Surabaya, each sub-task comprises specific work items. The project's scheduling utilizes a time schedule (S-curve). The project was initially scheduled for completion within 75 calendar days, from January 24, 2023, to April 17, 2023. However, during the execution, the project experienced delays. Specifically, on February 13, 2023, when the project should have already commenced, the progress of the project remained at 0%.

In accordance with the penalty regulations for project delays as stipulated in Article 120 of Presidential Regulation 70 of 2012 regarding penalties for delays, suppliers of goods/services who fail to complete work within the contractual time frame due to their fault are subject to a penalty for each day of delay amounting to 1/1000 (one per thousand) of the contract value or the contract portion value. In this context, if the project is not remedied with acceleration measures, the prescribed penalty will be enforced.

2.2.2. Identification of Project Financing

For the Drainage Channel Construction project on XYZ Street in Surabaya, the contract value is Rp. 2,125,338,733. To perform an analysis of project time acceleration that may impact the project cost, financing details, including direct and indirect costs, will be broken down, as a follow-up to the Time Cost Trade Off (TCTO) method. The following is a breakdown of the work items for the construction of the Drainage Channel on XYZ Street in Surabaya, which will be studied using the TCTO method. These work items will be rescheduled using the Critical Path Method.

2.2.3. Accelerating the Project Completion Time

Accelerating the project's duration leads to changes in both time and cost, which encompass:

a. Normal Time is the time required to complete an activity at a normal productivity level.
b. Crash Time is the shortest time possible to technically complete an activity.
c. Normal Cost represents the direct cost required to complete an activity within the normal time frame.
d. Crash Cost is the total direct cost to complete the work within the shortest time frame.

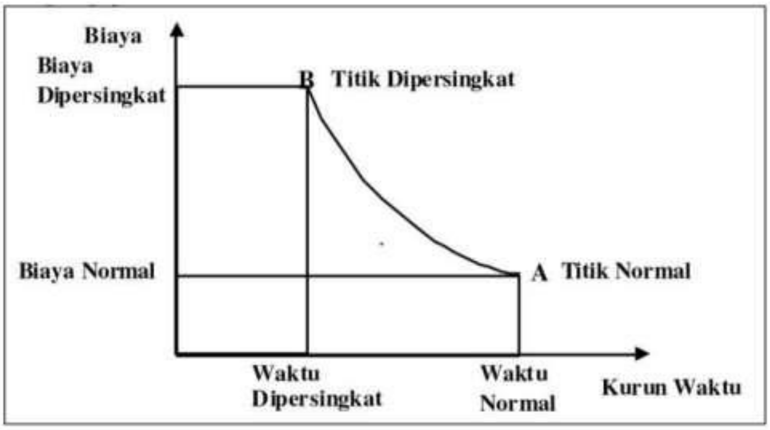
Overtime work productivity is calculated at 75% of normal productivity. Work productivity reflects the relationship between the quantity of work performed and the resources utilized.

a. $\text{Daily productivity} = \frac{Volume}{Normal\ duration}$

b. $\text{Productivity/hour} = \frac{Volume}{Normal\ duration}$

c. Daily productivity after crash = Daily productivity + (3 x hourly productivity x 75%)
d. From the daily productivity value after the crash, we can find the project completion time after being accelerated Crash duration =
e. Crash Cost and Cost Slope Crash cost is the cost used to carry out project activities within a period of time equal to the duration of the crash. The formula is as follows: Total overtime wage cost = number of workers x total additional overtime time x overtime cost/day
f. Crash cost = normal direct cost + total overtime wage cost
g. Cost slope is the addition of direct costs per unit time. Basically, it is necessary to find critical activities that will be accelerated which have the smallest cost slope. The formula for calculating the cost slope is found in equation 5 below.

$$Cost\ slope = \frac{Crash\ cost - Normal\ cost}{Normal\ duration - Crash\ duration}$$



Source: Soeharto, 1995

Figure 2. Normal and Shortened Time-Cost Relationship Chart for One Activity

3. RESULTS AND DISCUSSION

Based on primary and secondary data obtained from the Drainage Channel Project on XYZ Street, the following information has been gathered:

a. Project Owner: A
b. Planning Consultant: PT. A
c. Supervision Consultant: PT. B
d. Executing Contractor: PT. ABC
e. Budget Allocation: Rp. 2,500,000,000,-
f. Contract Value: Rp. 2,125,338,733,-
g. Execution Period: 72 working days
h. Start Date: January 24, 2023
i. Completion Date: April 17, 2023

j. Late Penalty: 0.1% per day
k. Deviation Limit: 10.00%

The following data pertains to the contract value of the Drainage Channel Project on XYZ Street.

REKAPITULASI

Nama Kegiatan : Penyelenggaraan Infrastruktur pada Permukiman di Kawasan Strategis Daerah Kabupaten/Kota
Nama Sub Kegiatan : Pembangunan dan Pengembangan Infrastruktur Kawasan Permukiman di Kawasan Strategis Daerah Kabupaten/Kota
Nama Pekerjaan : Pembangunan Saluran U-Ditch Uk. 60.80.120 (Jl. XYZ)
Lokasi : Kota Surabaya
Tahun : 2023

NO.	URAIAN PEKERJAAN	JUMLAH HARGA (Rp.)	
I	PEKERJAAN PENDAHULUAN	Rp	8,387,629.00
II	PEKERJAAN TANAH	Rp	230,190,777.68
III	PEKERJAAN PAVING	Rp	39,339,973.63
IV	PEKERJAAN SALURAN	Rp	1,636,301,198.95
V	PEKERJAAN LAIN-LAIN	Rp	500,000.00
	JUMLAH	Rp	1,914,719,579.27
	PPN 11%	Rp	210,619,153.72
	JUMLAH TOTAL	Rp	2,125,338,732.99
	DIBULATKAN	Rp	2,125,338,733.00
	TERBILANG : *Dua milyar seratus dua puluh lima juta tiga ratus tiga puluh delapan ribu tujuh ratus tiga puluh tiga rupiah*		

Source: Processed data (2023)
Figure 3. Recapitulation of Contract Value

From the recapitulation value, the RAB data for the Drainage Channel Project on Jl. XYZ can also be drawn.

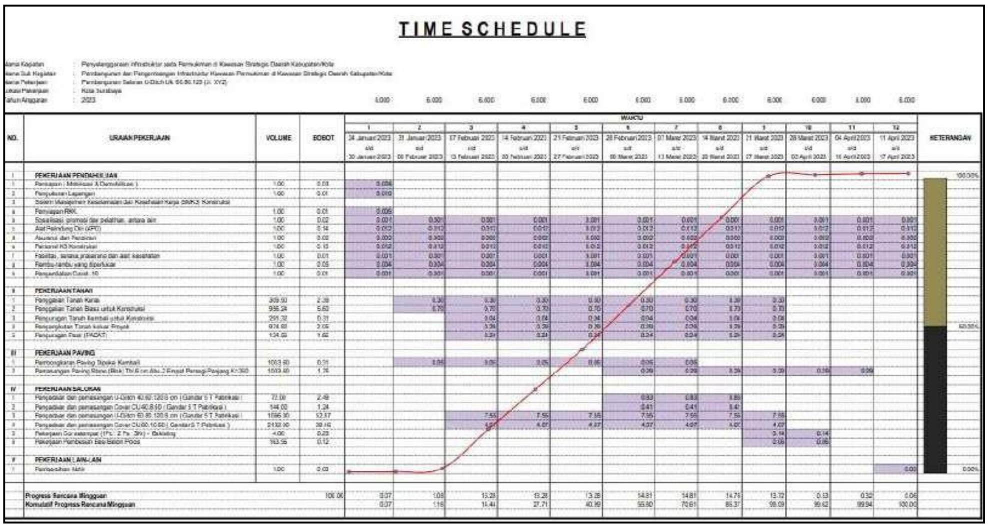
RENCANA ANGGARAN BIAYA

Nama Kegiatan : Penyelenggaraan Infrastruktur pada Permukiman di Kawasan Strategis Daerah Kabupaten/Kota
Nama Sub Kegiatan : Pembangunan dan Pengembangan Infrastruktur Kawasan Permukiman di Kawasan Strategis Daerah Kabupaten/Kota
Nama Pekerjaan : Pembangunan Saluran U-Ditch Uk. 60.80.120 (JL XYZ)
Lokasi : Kota Surabaya
Tahun : 2023
0

NO.	URAIAN PEKERJAAN	VOLUME		HARGA SATUAN (Rp.)		JUMLAH HARGA (Rp.)	
1	2	3		4		5	
I	PEKERJAAN PENDAHULUAN						
1	Persiapan (Mobilisasi & Demobilisasi)	1.00	Ls	Rp	500,000.00		500,000.00
2	Pengukuran Lapangan	1.00	Ls	Rp	200,000.00		200,000.00
3	Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) Konstruksi						
a	Penyiapan RKK.	1.00	Ls	Rp	100,000.00		100,000.00
b	Sosialisasi, promosi dan pelatihan, antara lain	1.00	Ls	Rp	300,000.00		300,000.00
c	Alat Pelindung Diri (APD)	1.00	Ls	Rp	2,660,000.00		2,660,000.00
d	Asuransi dan Perizinan	1.00	Ls	Rp	391,829.00		391,829.00
e	Personel K3 Konstruksi	1.00	Ls	Rp	2,860,800.00		2,860,800.00
f	Fasilitas, sarana,prasarana dan alat kesehatan	1.00	Ls	Rp	250,000.00		250,000.00
g	Rambu-rambu yang diperlukan	1.00	Ls	Rp	925,000.00		925,000.00
h	Pengendalian Covid -19	1.00	Ls	Rp	200,000.00		200,000.00
				JUMLAH			8,387,629.00
II	PEKERJAAN TANAH						
1	Penggalian Tanah Keras	309.90	m³	Rp	147,952.88	Rp	45,850,597.51
2	Penggalian Tanah Biasa untuk Konstruksi	956.24	m³	Rp	112,196.05	Rp	107,286,350.85
3	Pengurugan Tanah Kembali untuk Konstruksi	291.32	m³	Rp	20,107.33	Rp	5,857,667.38
4	Pengangkutan Tanah keluar Proyek	974.82	m³	Rp	40,337.50	Rp	39,321,801.75
5	Pengurugan Pasir (PADAT)	134.56	m³	Rp	236,878.42	Rp	31,874,360.20
				JUMLAH			230,190,777.68
III	PEKERJAAN PAVING						
1	Pembongkaran Paving Dipakai Kembali	1033.60	m²	Rp	5,703.60	Rp	5,895,240.96
2	Pemasangan Paving Stone (Blok) Tbl.6 cm Abu-2 Empat Persegi Panjang K=350	1033.60	m²	Rp	32,357.52	Rp	33,444,732.67
				JUMLAH			39,339,973.63
IV	PEKERJAAN SALURAN						
1	Pengadaan dan pemasangan U-Ditch 40.60.120.6 cm (Gandar 5 T Pabrikasi)	72.00	Pcs	Rp	661,405.58	Rp	47,621,201.76
2	Pengadaan dan pemasangan Cover CU 40.8.60 (Gandar 5 T Pabrikasi)	144.00	Pcs	Rp	164,699.34	Rp	23,716,704.96
3	Pengadaan dan pemasangan U-Ditch 60.80.120.8 cm (Gandar 5 T Pabrikasi)	1066.00	Pcs	Rp	949,580.67	Rp	1,012,252,994.22
4	Pengadaan dan pemasangan Cover CU 60.10.60 (Gandar 5 T Pabrikasi)	2132.00	Pcs	Rp	255,582.41	Rp	544,901,698.12
5	Pekerjaan Cor setempat (1Pc : 2 Ps : 3Kr) + Bekisting	4.06	m³	Rp	1,347,069.32	Rp	5,469,101.44
6	Pekerjaan Pembesian Besi Beton Polos	163.56	Kg	Rp	14,303.61	Rp	2,339,498.45
				JUMLAH			1,636,301,198.95
V	PEKERJAAN LAIN-LAIN						
1	Pembersihan Akhir	1.00	Ls	Rp	500,000.00	Rp	500,000.00
				JUMLAH			500,000.00

Source: Processed data (2023)
Figure 4. RAB (Budget Plan)

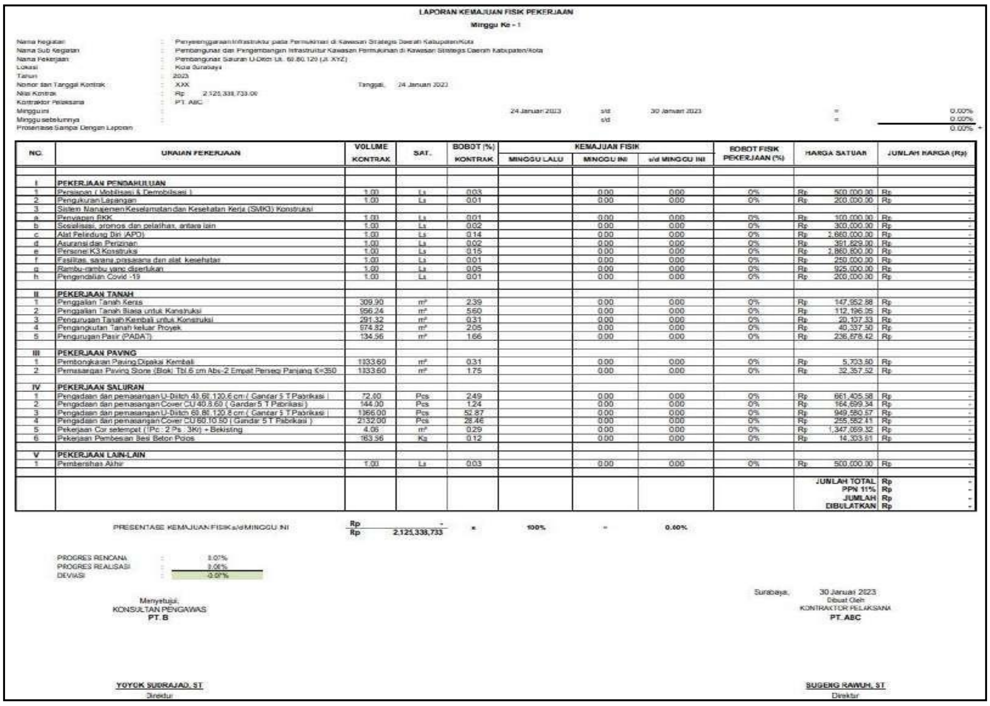
In addition to the recapitulation data and rab, the plan timeschedule data is also obtained.



Source: Processed data (2023)

Figure 5. Time Schedule Plan

The following is the weekly progress report data obtained from the Supervisory Consultant. From here is the reference for acceleration.



Source: Processed data (2023)

Figure 6. Week-1 Progress Report

LAPORAN KEMAJUAN FISIK PEKERJAAN

Minggu Ke - 2

Nama Kegiatan	: Penyelenggaraan Infrastruktur pada Permukiman di Kawasan Strategis Daerah Kabupaten/Kota				
Nama Sub Kegiatan	: Pembangunan dan Pengembangan Infrastruktur Kawasan Permukiman di Kawasan Strategis Daerah Kabupaten/Kota				
Nama Pekerjaan	: Pembangunan Saluran U-Ditch Uk. 60.80.120 (Jl. XYZ)				
Lokasi	: Kota Surabaya				
Tahun	: 2023				
Nomor dan Tanggal Kontrak	: XXX	Tanggal, 24 Januari 2023			
Nilai Kontrak	: Rp 2,125,338,733.00				
Kontraktor Pelaksana	: PT. ABC				
Minggu ini	:	31 Januari 2023	s/d	06 Februari 2023	= 0.00%
Minggu sebelumnya	:	24 Januari 2023	s/d	30 Januari 2023	= 0.00%
Prosentase Sampai Dengan Laporan					0.00% +

NO.	URAIAN PEKERJAAN	VOLUME KONTRAK	SAT.	BOBOT (%) KONTRAK	KEMAJUAN FISIK MINGGU LALU	KEMAJUAN FISIK MINGGU INI	KEMAJUAN FISIK s/d MINGGU INI	BOBOT FISIK PEKERJAAN (%)	HARGA SATUAN	JUMLAH HARGA (Rp)
I	**PEKERJAAN PENDAHULUAN**									
1	Persiapan (Mobilisasi & Demobilisasi)	1.00	Ls	0.03	0.00	0.00	0.00	0%	Rp 500,000.00	Rp -
2	Pengukuran Lapangan	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 200,000.00	Rp -
3	Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) Konstruksi				0.00					
a	Penyiapan RKK	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 100,000.00	Rp -
b	Sosialisasi, promosi dan pelatihan, antara lain	1.00	Ls	0.02	0.00	0.00	0.00	0%	Rp 300,000.00	Rp -
c	Alat Pelindung Diri (APD)	1.00	Ls	0.14	0.00	0.00	0.00	0%	Rp 2,660,000.00	Rp -
d	Asuransi dan Perizinan	1.00	Ls	0.02	0.00	0.00	0.00	0%	Rp 391,829.00	Rp -
e	Personel K3 Konstruksi	1.00	Ls	0.15	0.00	0.00	0.00	0%	Rp 2,860,800.00	Rp -
f	Fasilitas, sarana prasarana dan alat kesehatan	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 250,000.00	Rp -
g	Rambu-rambu yang diperlukan	1.00	Ls	0.05	0.00	0.00	0.00	0%	Rp 925,000.00	Rp -
h	Pengendalian Covid -19	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 200,000.00	Rp -
II	**PEKERJAAN TANAH**									
1	Penggalian Tanah Keras	309.90	m^3	2.39	0.00	0.00	0.00	0%	Rp 147,952.88	Rp -
2	Penggalian Tanah Biasa untuk Konstruksi	956.24	m^3	5.60	0.00	0.00	0.00	0%	Rp 112,196.05	Rp -
3	Pengurugan Tanah Kembali untuk Konstruksi	291.32	m^3	0.31	0.00	0.00	0.00	0%	Rp 20,107.33	Rp -
4	Pengangkutan Tanah keluar Proyek	974.82	m^3	2.05	0.00	0.00	0.00	0%	Rp 40,337.50	Rp -
5	Pengurugan Pasir (PADAT)	134.56	m^3	1.66	0.00	0.00	0.00	0%	Rp 236,878.42	Rp -
III	**PEKERJAAN PAVING**									
1	Pembongkaran Paving Dipakai Kembali	1033.60	m^2	0.31	0.00	0.00	0.00	0%	Rp 5,703.60	Rp -
2	Pemasangan Paving Stone (Blok) Tbl.6 cm Abu-2 Empat Persegi Panjang K=350	1033.60	m^2	1.75	0.00	0.00	0.00	0%	Rp 32,357.52	Rp -
IV	**PEKERJAAN SALURAN**									
1	Pengadaan dan pemasangan U-Ditch 40.60.120.6 cm (Gandar 5 T Pabrikasi)	72.00	Pcs	2.49	0.00	0.00	0.00	0%	Rp 661,405.58	Rp -
2	Pengadaan dan pemasangan Cover CU 40.8.60 (Gandar 5 T Pabrikasi)	144.00	Pcs	1.24	0.00	0.00	0.00	0%	Rp 164,699.34	Rp -
3	Pengadaan dan pemasangan U-Ditch 60.80.120.8 cm (Gandar 5 T Pabrikasi)	1066.00	Pcs	52.87	0.00	0.00	0.00	0%	Rp 949,580.67	Rp -
4	Pengadaan dan pemasangan Cover CU 60.10.60 (Gandar 5 T Pabrikasi)	2132.00	Pcs	28.46	0.00	0.00	0.00	0%	Rp 255,582.41	Rp -
5	Pekerjaan Cor setempat (1Pc : 2 Ps : 3Kr) + Bekisting	4.06	m^3	0.29	0.00	0.00	0.00	0%	Rp 1,347,069.32	Rp -
6	Pekerjaan Pembesian Besi Beton Polos	163.56	Kg	0.12	0.00	0.00	0.00	0%	Rp 14,303.61	Rp -
V	**PEKERJAAN LAIN-LAIN**									
1	Pembersihan Akhir	1.00	Ls	0.03	0.00	0.00	0.00	0%	Rp 500,000.00	Rp -
									JUMLAH TOTAL	Rp -
									PPN 11%	Rp -
									JUMLAH	Rp -
									DIBULATKAN	Rp -

PRESENTASE KEMAJUAN FISIK s/d MINGGU INI (Rp - / Rp **2,125,338,733**) x **100%** = **0.00%**

PROGRES RENCANA : 1.16%
PROGRES REALISASI : 0.00%
DEVIASI : -1.16%

Surabaya, 06 Februari 2023

Menyetujui,
KONSULTAN PENGAWAS
PT. B

Dibuat Oleh
KONTRAKTOR PELAKSANA
PT. ABC

YOYOK SUDRAJAD, ST
Direktur

SUGENG RAWUH, ST
Direktur

Source: Processed data (2023)

Figure 7. Week-2 Progress Report

LAPORAN KEMAJUAN FISIK PEKERJAAN

Minggu Ke - 3

Nama Kegiatan	: Penyelenggaraan Infrastruktur pada Permukiman di Kawasan Strategis Daerah Kabupaten/Kota				
Nama Sub Kegiatan	: Pembangunan dan Pengembangan Infrastruktur Kawasan Permukiman di Kawasan Strategis Daerah Kabupaten/Kota				
Nama Pekerjaan	: Pembangunan Saluran U-Ditch Uk. 60.80.120 (Jl. XYZ)				
Lokasi	: Kota Surabaya				
Tahun	: 2023				
Nomor dan Tanggal Kontrak	: XXX	Tanggal, 24 Januari 2023			
Nilai Kontrak	: Rp 2,125,338,733.00				
Kontraktor Pelaksana	: PT. ABC				
Minggu ini	:	07 Februari 2023	s/d	13 Februari 2023	= 0.00%
Minggu sebelumnya	:	31 Januari 2023	s/d	06 Februari 2023	= 0.00%
Prosentase Sampai Dengan Laporan					0.00% +

NO.	URAIAN PEKERJAAN	VOLUME KONTRAK	SAT.	BOBOT (%) KONTRAK	KEMAJUAN FISIK MINGGU LALU	KEMAJUAN FISIK MINGGU INI	KEMAJUAN FISIK s/d MINGGU INI	BOBOT FISIK PEKERJAAN (%)	HARGA SATUAN	JUMLAH HARGA (Rp)
I	**PEKERJAAN PENDAHULUAN**									
1	Persiapan (Mobilisasi & Demobilisasi)	1.00	Ls	0.03	0.00	0.00	0.00	0%	Rp 500,000.00	Rp -
2	Pengukuran Lapangan	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 200,000.00	Rp -
3	Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) Konstruksi									
a	Penyiapan RKK	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 100,000.00	Rp -
b	Sosialisasi, promosi dan pelatihan, antara lain	1.00	Ls	0.02	0.00	0.00	0.00	0%	Rp 300,000.00	Rp -
c	Alat Pelindung Diri (APD)	1.00	Ls	0.14	0.00	0.00	0.00	0%	Rp 2,660,000.00	Rp -
d	Asuransi dan Perizinan	1.00	Ls	0.02	0.00	0.00	0.00	0%	Rp 391,829.00	Rp -
e	Personel K3 Konstruksi	1.00	Ls	0.15	0.00	0.00	0.00	0%	Rp 2,860,800.00	Rp -
f	Fasilitas, sarana prasarana dan alat kesehatan	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 250,000.00	Rp -
g	Rambu-rambu yang diperlukan	1.00	Ls	0.05	0.00	0.00	0.00	0%	Rp 925,000.00	Rp -
h	Pengendalian Covid -19	1.00	Ls	0.01	0.00	0.00	0.00	0%	Rp 200,000.00	Rp -
II	**PEKERJAAN TANAH**									
1	Penggalian Tanah Keras	309.90	m^3	2.39	0.00	0.00	0.00	0%	Rp 147,952.88	Rp -
2	Penggalian Tanah Biasa untuk Konstruksi	956.24	m^3	5.60	0.00	0.00	0.00	0%	Rp 112,196.05	Rp -
3	Pengurugan Tanah Kembali untuk Konstruksi	291.32	m^3	0.31	0.00	0.00	0.00	0%	Rp 20,107.33	Rp -
4	Pengangkutan Tanah keluar Proyek	974.82	m^3	2.05	0.00	0.00	0.00	0%	Rp 40,337.50	Rp -
5	Pengurugan Pasir (PADAT)	134.56	m^3	1.66	0.00	0.00	0.00	0%	Rp 236,878.42	Rp -
III	**PEKERJAAN PAVING**									
1	Pembongkaran Paving Dipakai Kembali	1033.60	m^2	0.31	0.00	0.00	0.00	0%	Rp 5,703.60	Rp -
2	Pemasangan Paving Stone (Blok) Tbl.6 cm Abu-2 Empat Persegi Panjang K=350	1033.60	m^2	1.75	0.00	0.00	0.00	0%	Rp 32,357.52	Rp -
IV	**PEKERJAAN SALURAN**									
1	Pengadaan dan pemasangan U-Ditch 40.60.120.6 cm (Gandar 5 T Pabrikasi)	72.00	Pcs	2.49	0.00	0.00	0.00	0%	Rp 661,405.58	Rp -
2	Pengadaan dan pemasangan Cover CU 40.8.60 (Gandar 5 T Pabrikasi)	144.00	Pcs	1.24	0.00	0.00	0.00	0%	Rp 164,699.34	Rp -
3	Pengadaan dan pemasangan U-Ditch 60.80.120.8 cm (Gandar 5 T Pabrikasi)	1066.00	Pcs	52.87	0.00	0.00	0.00	0%	Rp 949,580.67	Rp -
4	Pengadaan dan pemasangan Cover CU 60.10.60 (Gandar 5 T Pabrikasi)	2132.00	Pcs	28.46	0.00	0.00	0.00	0%	Rp 255,582.41	Rp -
5	Pekerjaan Cor setempat (1Pc : 2 Ps : 3Kr) + Bekisting	4.06	m^3	0.29	0.00	0.00	0.00	0%	Rp 1,347,069.32	Rp -
6	Pekerjaan Pembesian Besi Beton Polos	163.56	Kg	0.12	0.00	0.00	0.00	0%	Rp 14,303.61	Rp -
V	**PEKERJAAN LAIN-LAIN**									
1	Pembersihan Akhir	1.00	Ls	0.03	0.00	0.00	0.00	0%	Rp 500,000.00	Rp -
									JUMLAH TOTAL	Rp -
									PPN 11%	Rp -
									JUMLAH	Rp -
									DIBULATKAN	Rp -

PRESENTASE KEMAJUAN FISIK s/d MINGGU INI (Rp - / Rp **2,125,338,733**) x **100%** = **0.00%**

PROGRES RENCANA : 14.44%
PROGRES REALISASI : 0.00%
DEVIASI : -14.44%

Surabaya, 13 Februari 2023

Menyetujui,
KONSULTAN PENGAWAS
PT. B

Dibuat Oleh
KONTRAKTOR PELAKSANA
PT. ABC

YOYOK SUDRAJAD, ST
Direktur

SUGENG RAWUH, ST
Direktur

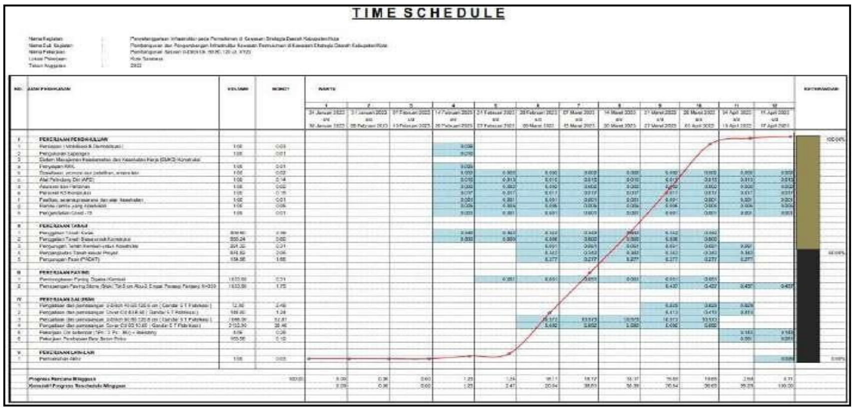
Source: Processed data (2023)

Figure 8. Week-3 Progress Report

Based on the data from the Supervisory Consultant's weekly progress report, the deviation of the project is -14.16% while the limit is - 10.00%, so it is necessary to accelerate so that the project does not experience delays.

3.1. Critical Path Method

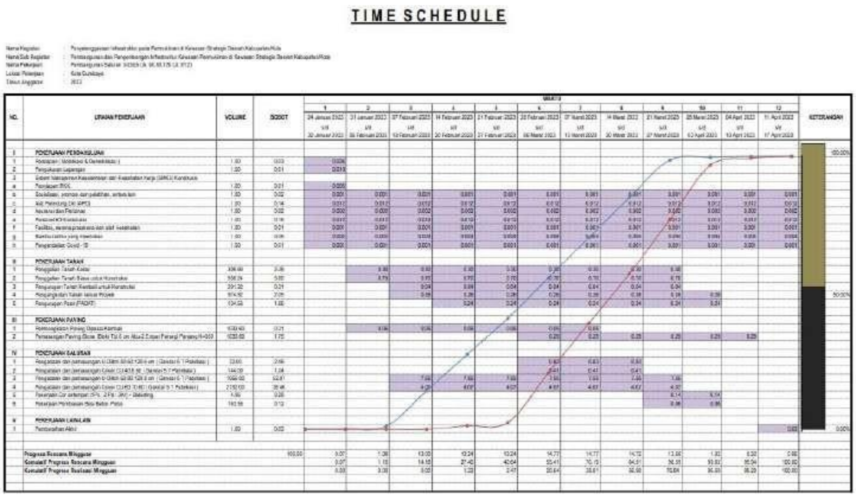
Based on the data that has been delayed, we reschedule with the remaining time, namely in week 4 on February 14, 2023 until the end of work on April 17. The following are the results of the reschedule with CPM calculations:



Source: Processed data (2023)

Figure 9. Acceleration Reschedule Results

From the reschedule results, an S-curve comparison of the schedule plan can be drawn, so that it is obtained:



Source: Processed data (2023)

Figure 10. Comparison of S-Curve of Plan and Reschedule

After getting the reschedule results, we can input it into Ms. Project so that the critical trajectory is known.

3.2. List of Critical Activities

Based on the results of Ms. Project analysis for project scheduling, critical activities are obtained. The list of critical activities under normal conditions can be seen in Table 1:

Table 1. List of Critical Activities

No. Task	Task Name	Duration
	Drainage Channel Project on Jl. XYZ	
3	Preparation (Mobilization & Demobilization)	1
16	Common Ground Excavation for Construction	40
26	Procurement and installation of U-Diitch 60.80.120.8 cm (Fabricated 5 T Axle)	29
27	Procurement and installation of CU Cover 60.10.60 (Fabricated 5 T Axle)	29
28	Local Cast Work (1Pc : 2 Ps : 3Kr) + Formwork	11
29	Plain Concrete Iron Fixing Work	11

Source: Processed data (2023)

The given data pertains to the critical path analysis, where the original duration of a project was 57 days, resulting in a 6-day overtime situation. In light of this, the focus is on identifying alternative acceleration strategies to ensure the project is completed on schedule.

The selection criteria for the critical path activities are as follows:

a. The chosen critical activities involve resource work, i.e., tasks that require labor resources and can be expedited through resource optimization.
b. These critical activities offer potential for acceleration through either overtime work or increasing the labor force, enabling adjustments to be made to meet the project's deadline.
c. Another option is to consider omitting one of the critical activities, provided that its omission does not lead to severe adverse consequences for the overall project.

In an academic context, these criteria outline the basis for selecting specific critical path activities for acceleration, highlighting the importance of resource allocation, workforce adjustments, and the potential consequences of omitting certain tasks.

3.3. Application of Time Cost Trade Off Method

In the context of planning for overtime work, the standard working hours consist of 8 normal working hours with a 1-hour break (from 08:00 to 17:00). Overtime work is performed beyond the regular working hours (from 19:00 to 22:00). According to the decision of the Minister of Manpower Number KEP.102/MEN/VI/2004, the regulations regarding overtime wages are as follows:

a. Overtime work can only be performed for a maximum of 3 hours in one day and up to 14 hours in one week.
b. Employers must provide food and beverages with a minimum of 1,400 calories when overtime work is performed for 3 hours or more.
c. For the first hour of overtime work, employees should be paid 1.5 times the hourly wage.
d. For each subsequent hour of overtime work, employees should be paid twice the hourly wage.

The fundamental principle in determining the items to be expedited is to seek those with the lowest additional costs but the greatest impact. In this context, the selected item for acceleration is ordinary earth excavation. Based on the available data, the volume of this item is 956.24 cubic meters. An analysis of the ordinary earth excavation item is provided in Figure 11 below:

ANALISA HARGA SATUAN

KEGIATAN :
PEKERJAAN :
ITEM PEMBAYARAN No. :
JENIS PEKERJAAN : Penggalian Tanah Biasa untuk Konstruksi
SATUAN PEMBAYARAN : m^3

No	KOMPONEN	SATUAN	KOEFISIEN	HARGA SATUAN (Rp.)	TOTAL (Rp.)
A.	TENAGA				
1	Mandor	O.H	0.0252	120,000.00	3,024.49
2	Pembantu Tukang	O.H	0.7572	80,000.00	60,577.66
			JUMLAH HARGA TENAGA		63,602.15
B.	BAHAN				
			JUMLAH HARGA BAHAN		-
C.	ALAT				
			JUMLAH HARGA ALAT		-
C.	JUMLAH HARGA TENAGA, BAHAN DAN PERALATAN		(A + B)		63,602.15

Source: Processed data (2023)

Figure 11. Unit Price Analysis of Ordinary Land Excavation Items for Construction

Here is the translation of the provided calculation:

a. Alternative 1 (Overtime Hours Addition)

From the critical path analysis, it was determined that there would be overtime for 6 days. In this project, normal working hours are 8 hours, starting from 08:00 to 17:00. Adhering to the requirements of the Minister of Manpower's Decision Number KEP.102/MEN/VI/2004, as specified in articles 3, 7, and 11, which stipulate that overtime work can only be performed for a maximum of 3 hours, the required time is calculated as follows:

Given:

- Normal working hours = 8 hours
- Overtime = 6 days
  = 6 x 8
  = 48 hours

- Max. Overtime in 1 day = 3 hours

Therefore, the required number of days = 48 / 3
= 16 days

No 1	Namadan Spesifikasi 2	Satuan 3	Harga(Rp) Upah	
II	TENAGA			
1	Mandor	hr	Rp	120,000.00
2	Tukang Batu	hr	Rp	100,000.00
3	Tukang Besi	hr	Rp	100,000.00
4	Tukang Kayu	hr	Rp	100,000.00
5	Pembantu Tukang	hr	Rp	80,000.00
6	Petugas Survey	hr	Rp	80,000.00
7	Surveyor Geodesi	hr	Rp	100,000.00

Source: Processed data (2023)
Figure 12. Actual Wages Price List

Based on the provided data, we can calculate the required workforce as follows:
Given:

- Volume = 956.24 cubic meters
- Foreman Coefficient = 0.0252 O.H
- Assistant Mason Coefficient = 0.7572 O.H
- Foreman's Wage = Rp. 120,000 per day
- Assistant Mason's Wage = Rp. 80,000 per day
- X = Normal Foreman Requirement
- Y = Normal Assistant Mason Requirement

We can calculate as follows:
X = Volume x Foreman Coefficient
= 956.24 x 0.0252
= 24.10

So, to complete the excavation work with a volume of 956.24 cubic meters, it requires approximately 24.10 foremen. When converted to days, if the reschedule time is 40 days:
= X : 40
= 24.10 : 40
= 0.60 ~ 1 O.H (Overtime Hour)

Based on the overtime calculation, it requires 16 days of overtime work, which means the cost to be incurred is as follows:

- Foreman's Wage = Rp. 120,000 x 1.5
= Rp. 180,000

Then, the time taken to achieve acceleration is:
40 - 6 = 34 days

This implies 16 days of overtime and 18 days of normal work. Therefore, the cost of foreman wages for the ordinary earth excavation work item for construction is calculated as:

- Overtime Time = Rp. 180,000 x 16 x 1 = Rp. 2,880,000
- Normal Time = Rp. 120,000 x 18 x 1 = Rp. 2,160,000
-

So, the total cost is Rp. 5,040,000.
For the Assistant Mason Requirement:
X = Volume x Assistant Mason Coefficient
= 956.24 x 0.7572
= 724.08

To complete the excavation work with a volume of 956.24 cubic meters, it requires approximately 724.08 assistant masons. When converted to days, if the reschedule time is 40 days:
= X : 40
= 724.08 : 40
= 18.10 ~ 18 O.H (Overtime Hour)

Based on the overtime calculation, it requires 16 days of overtime work, which means the cost to be incurred is as follows:
Assistant Mason's Wage = Rp. 80,000 x 1.5
= Rp. 120,000

Then, the time taken to achieve acceleration is:
40 - 6 = 34 days

This implies 16 days of overtime and 18 days of normal work. Therefore, the cost of assistant mason wages for the ordinary earth excavation work item for construction is calculated as:

- Overtime Time = Rp. 120,000 x 16 x 18 = Rp. 34,560,000
- Normal Time = Rp. 80,000 x 18 x 18 = Rp. 25,920,000

So, the total cost is Rp. 60,480,000.
In conclusion, for the ordinary earth excavation work item in construction, the cost to be incurred is Rp. 65,520,000.

b. Alternative 2 (Addition of Manpower)
The addition of manpower is done by recalculating the labor requirements for each activity based on the duration of acceleration or crashing, which will be achieved without increasing the number of working hours per day.

Calculation for the addition of manpower based on the normal duration:
Given:

- Volume = 956.24 cubic meters
- Foreman Coefficient = 0.0252 O.H
- Assistant Mason Coefficient = 0.7572 O.H
- Foreman's Wage = Rp. 120,000 per day
- Assistant Mason's Wage = Rp. 80,000 per day
- X = Total Foreman Requirement
- Y = Total Worker Requirement

From the data in Ms. Project, there is overtime for 6 days. Originally, the work was scheduled from February 14, 2023, to April 3, 2023, but it was extended to April 10, 2023, to meet the rescheduled timeline. This necessitates the addition of manpower. The calculation to determine the required manpower is as follows:

We can calculate as follows:

X = Volume x Foreman Coefficient
= 956.24 x 0.0252
= 24.10

So, to complete the excavation work with a volume of 956.24 cubic meters, it requires approximately 24.10 foremen. When converted to days, if the reschedule time is 40 days:

= X / 40
= 24.10 / 40
= 0.60 ~ 1 O.H (Overtime Hour)

Then, the time taken to achieve acceleration is:

40 - 6 = 34 days

This implies that if the time is reduced to 34 days, we need to calculate the additional foremen required, as follows:

= X / 34
= 24.10 / 34
= 0.71 ~ 1 O.H

This means the cost of foreman wages for the ordinary earth excavation work item for construction is calculated as:

- Foreman's Wage = Rp. 120,000 x 34 x 2
  = Rp. 8,160,000

For the Assistant Mason Requirement:

X = Volume x Assistant Mason Coefficient
= 956.24 x 0.7572
= 724.08

To complete the excavation work with a volume of 956.24 cubic meters, it requires approximately 724.08 assistant masons. When converted to days, if the reschedule time is 40 days:

= X / 40
= 724.08 / 40
= 18.10 ~ 18 O.H (Overtime Hour)

Then, the time taken to achieve acceleration is:

40 - 6 = 34 days

This implies that if the time is reduced to 34 days, we need to calculate the additional assistant masons required, as follows:

= X : 34
= 724.08 : 34
= 21.30 ~ 22 O.H

This means the cost of assistant mason wages for the ordinary earth excavation work item for construction is calculated as:

- Assistant Mason's Wage = Rp. 80,000 x 34 x 22
  = Rp. 59,840,000

In conclusion, for the ordinary earth excavation work item in construction, the cost to be incurred is Rp. 68,000,000.

c. Alternative 3 (New Item Addition)

In this third alternative, the intention is to replace the ordinary earth excavation, which originally involved manual labor, with the introduction of a new item that uses heavy machinery (excavator). To determine the cost associated with this alternative, it is essential to calculate the productivity of the heavy machinery. Here are the specifications of the heavy machinery to be used and its productivity calculation:

The productivity calculation for the excavator, based on the type of work being undertaken, is as follows:

- Equipment Brand/Type: Hitachi
- Bucket Capacity (q1): 1 cubic meter
- Bucket Factor (K): 0.8
- Work Efficiency (E): 0.067
- Effective Working Hours: 8 hours
- Type of Soil: Ordinary Earth
- Digging Time: 6 seconds
- Swing Time: 5 seconds
- Dumping Time: 4 seconds
- Volume: 956.24 cubic meters
- Production per Cycle (q): q1 x K = 1 x 0.8 = 0.8 m3

- Cycle Time (Cm) = digging time + (swing time x 2) + dumping time
  = 6 + (5 x 2) + 4
  = 20 seconds

The production rate of the excavator can be calculated using the formula below:
Production per hour (m3/hour) for ordinary earth

$$P = \frac{q \, x \, 3600 \, x \, E}{CM} = \frac{0{,}8 \, x \, 3600 \, x \, 0{,}067}{20} \, x \, 0{,}8 = 7{,}7184 \, m3/ \text{ hour}$$

Excavator Daily Production = 7.7184 m^3/hour x 8 hours = 61.7472 m^3/day
Calculation of Excavator Usage Time:

- Production per Unit = 7.7184 m^3/hour
- Number of Excavators = 1 unit with an operating time of 8 hours
- Production of 1 unit per day = 8 x 7.7184 = 61.7472 m^3/day
- Volume = 956.24 m^3

$$= \frac{956{,}24}{61{,}7472}$$

= 15,4863 days ~ 16 days

Then, the cost to be incurred can be calculated as follows:
Time = 16 days = 16 x 8 = 128 hours
Excavator Rental Rate = Rp. 75,000 per hour
X = 128 x Rp. 75,000 = Rp. 9,600,000

After obtaining the excavator cost, it should be included in the analysis of ordinary earth excavation using heavy machinery, as shown in Figure 13:

ANALISA HARGA SATUAN

KEGIATAN :
PEKERJAAN :
ITEM PEMBAYARAN No. :
JENIS PEKERJAAN : Penggalian Tanah Biasa (Menggunakan Alat Berat)
SATUAN PEMBAYARAN : m^3

No	KOMPONEN	SATUAN	KOEFISIEN	HARGA SATUAN (Rp.)	TOTAL (Rp.)
A.	TENAGA				
1	Mandor	O.H	0.0070	120,000.00	840.00
2	Pembantu Tukang	O.H	0.2260	80,000.00	18,080.00
			JUMLAH HARGA TENAGA		18,920.00
B.	BAHAN				
			JUMLAH HARGA BAHAN		-
C.	ALAT				
	Sewa Mini Excavator	Jam	0.0670	75,000.00	5,025.00
	Sewa Dump Truck 5,00 T (8-10 m3)	Jam	0.0670	62,500.00	4,187.50
			JUMLAH HARGA ALAT		9,212.50
C.	JUMLAH HARGA TENAGA, BAHAN DAN PERALATAN		(A + B)		28,132.50

Source: Processed data (2023)

Figure 13. Analysis of Ordinary Land Excavation (Using Heavy Equipment)

From the provided diagram, the total expenditure for the Ordinary Earth Excavation item can be calculated as follows:

We can calculate as follows:

X = Volume x Foreman Coefficient
= 956.24 x 0.007
= 6.69

So, to complete the excavation work with a volume of 956.24 m³, it requires approximately 6.69 foremen. When converted to days, based on the previous calculation of 16 days:

= X / 16
= 6.69 / 16
= 0.42 ~ 1 O.H (Overtime Hour)

This means the cost of foreman wages for the ordinary earth excavation work item for construction is calculated as:

- Foreman's Wage = Rp. 120,000 x 16 x 1
  = Rp. 1,920,000

For the Assistant Mason Requirement:

X = Volume x Assistant Mason Coefficient
= 956.24 x 0.226
= 216.11

So, to complete the excavation work with a volume of 956.24 m³, it requires approximately 216.11 assistant masons. When converted to days, based on the previous calculation of 16 days:

= X / 16
= 216.11 / 16
= 13.51 ~ 14 O.H (Overtime Hour)

This means the cost of assistant mason wages for the ordinary earth excavation work item for construction is calculated as:

- Assistant Mason's Wage = Rp. 80,000 x 16 x 14
  = Rp. 17,920,000

As for the Dump Truck calculation, the rental period is already known, and the cost is calculated as follows:

We can calculate as follows:

Time = 16 days = 16 x 8 = 128 hours

Excavator Rental Rate = Rp. 62,500 per hour

X = 128 x Rp. 62,500 = Rp. 8,000,000

So, for the ordinary earth excavation work item in construction, the cost to be incurred is Rp. 37,440,000.

For easier comparison, a table is created to summarize the acceleration options. Here is the comparison table:

Table 2. Comparison of Acceleration

No.	Alternative Type	Cost Plan	Duration Early	Cost of Acceleration	Duration Acceleration
1.	Alternative 1 (Additional overtime hours)	Rp. 60.818.919,-	40 hari	Rp. 65.520.000,-	34 days
2.	Alternative 2 (Increase in manpower)	Rp. 60.818.919,-	40 hari	Rp. 68.000.000,-	34 days
3.	Alternative 3 (New Addendum Item) replacing manual excavation of ordinary soil to ordinary soil excavation with heavy equipment	Rp. 60.818.919,-	40 hari	Rp. 37.440.000,-	16 days

Source: Processed data (2023)

4. CONCLUSION

In the analysis of project acceleration through various alternatives, it is evident that each approach comes with distinct cost implications and timeframe reductions. The decision to choose among the alternatives should take into consideration both budget constraints and the urgency of project completion. For future research, a broader range of acceleration methods and the incorporation of real-world site practices and habits should be explored to enrich the analysis and better reflect the complexities of construction project management.

Furthermore, future studies could benefit from the inclusion of additional variables that influence decision-making in project acceleration. This may involve considering factors like resource availability, environmental impact, and potential risks, providing a more holistic perspective for project managers to make informed decisions regarding acceleration strategies.

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