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Cost Control Analysis Using the Critical Path Method in the Construction of Disaster Emergency Response Handling Projects in the Sumber Pasinan River, Mojokerto Regency

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ABSTRACT

The landslide on the banks of the *Sumber Pasinan* River in Mojokerto Regency, East Java, has caused significant damage, including the displacement of river rocks and exacerbated erosion due to frequent flooding during the rainy season. As a *Swakelola* project, the construction of the river stone pair must be completed efficiently within a minimal timeframe and cost. This study aims to estimate the costs associated with accelerating the construction project using the Critical Path Method (CPM). A quantitative approach was employed, applying project management theories to address practical challenges in the Disaster Emergency Response Handling Project. Based on the results of the acceleration of the working days analyzed using the Critical Path Method (CPM), there was an acceleration of 24 days, which required the addition of 11 workers. The cost of acceleration caused an increase in labor costs (cost slope) of Rp16,486,500.00 compared to the previous cost budget plan. The findings demonstrate the effectiveness of the CPM in optimizing project timelines while highlighting the need for careful cost management. This research provides valuable insights for contractors and project managers, offering strategic recommendations to enhance time and cost efficiency in similar construction projects. The implications of this study extend to improved disaster response planning and resource allocation, ensuring timely and cost-effective project completion.

Keywords: Construction Management; Critical Path Method (CPM); Cost; Microsoft Project; Project Management

INTRODUCTION

Infrastructure growth in various regional sectors is progressing rapidly and improving, in line with economic development and community needs. This triggers the expansion of regional infrastructure facilities. Infrastructure development must be well planned and managed through effective management. Good management can be done scientifically and intensively to handle special activities in the form of projects (*Mutia Astari & Momon Subagyo, 2021*).

The landslide on the banks of the *Sumber Pasinan* River in Mojokerto Regency, East Java, caused the existing pair of river stones to be damaged and displaced. In addition, the rise of water from the *Sumber Pasinan* River, which often overflows during the rainy season, exacerbates erosion on the riverbanks due to rain. This further worsens the condition of the *Sumber Pasinan* River banks. The impact of the landslide on the riverbank threatened the surrounding houses located by the banks. If not treated immediately, erosion will become more extensive during the rainy season and may cause further landslides (Chen et al., 2011; Perrucci et al., 2025; Wang et al., 2021; Yaqin et al., 2023).

A natural disaster is defined as the occurrence of a natural condition or phenomenon that threatens or acts dangerously in a certain space and time. Landslides are one type of natural disaster characterized by the movement of rock masses, rock fragments, or soil down a slope due to gravity. The term landslide is generally used for mass movements in hills, where the larger the landslide, the greater the mass displacement. In recent decades, landslides have received considerable attention as they are among the most widespread disasters globally in terms of loss of life and socio-economic damage. This situation is caused by sharp population growth, which has led to significant economic and human losses. Landslides cause thousands of deaths and infrastructure damage each year worldwide. Landslides are an umbrella term for various ground movements that cause actual displacement of earth, rocks, and plants due to gravity (*Sunita Devi, 2020*). Landslides occur due to deformation of rocks and soil on slopes influenced by rainfall, human activities, slope topography, geology, vegetation, and other factors (*Yuliana Yamco, 2022*).

The movement of land masses, better known as avalanches, refers to soil or rock moving downward or away from its original position. This landslide is influenced by several earth surface elements such as the impulse of water, wind, and the earth's gravitational force. Landslides result from slope imbalance disturbances, where the slope's ability to resist soil or rock shear is lower than the weight of the soil or rock mass itself (*Anakta Sebayang, 2022*).

Slope reinforcement is a very important aspect of river projects, as it affects topography and environmental stability. Slopes can pose hazards such as landslides, erosion, and infrastructure damage. Therefore, slope reinforcement is necessary to prevent erosion and landslides that can damage infrastructure. Each project faces different challenges related to soil quality, requiring special treatment for each slope reinforcement. The soil strengthening method is a good choice for slopes on riverbanks because it can reduce the risk of landslides (*Rifqi Riftyan Pranaya, 2023*).

A soil retaining wall is a construction designed to hold loose or natural soil and prevent collapse of sloping soil or slopes whose stability cannot be guaranteed by the soil itself. Retained soil exerts active pressure on the wall structure, which may cause the structure to tip over or shift (*Darlina Tanjung, 2024*).

A river is a stream characterized by geometric features such as cuts, elongated cuts, and slopes that can change over time depending on flow, base material, and banks. Rivers can hold not only rainwater from surface runoff but also domestic sewage and surrounding drainage water. Rivers have different shapes and characteristics influenced by many factors including topography, climate, and natural phenomena during their formation. Rivers carry water from upstream to downstream. One function of river walls is to prevent erosion caused by flowing water. A key factor in the erosion process is river morphology because open river flow has a free surface. Erosion is a natural phenomenon occurring in water bodies. It can take place naturally as part of river morphology, such as through curvature or narrowing of river flow, or due to river structures obstructing flow. Erosion will wear away riverbanks if they are not protected with *pair of facing stones* or concrete. Stonework also provides a foundation by countering soil pressure. Lateral soil pressure is a planning parameter when constructing foundations or retaining walls. Underground structures require quantitative estimation of lateral soil pressure for planning and stability analysis, especially because soil is labile and easily movable (*Supratikno, 2023*).

Construction work is complex involving many work items, high costs, various tools, and numerous workers. Therefore, a management system is needed to control all activities so that work proceeds according to plan with excellent performance, allowing completion before the planned time and at minimal cost (*Andi Marini Indriani, 2022*).

Construction is a complex and dynamic activity, causing construction projects to often deviate from plans. Due to these variations, consistent and integrated control mechanisms are needed for project performance. Time and cost control is crucial to success in construction projects (*Andi Permana Sidiq, 2022*).

Selecting a professional workforce according to job requirements plays an important role. Choosing the right construction materials determines whether work can be carried out on time and within cost. Equally important is the selection of work methods; mistakes here cause delays and wasted materials, thus method choices must be carefully considered. The use of company assets such as equipment also supports performance, enabling cost savings (*Andi Marini Indriani, 2022*).

During construction projects, discrepancies often occur between planned schedules and field realization, causing longer implementation time and increased costs, thus hampering project completion. Common delay causes include changes in project conditions, design changes, weather factors, inadequate workers/materials/equipment, and planner errors or specification issues. Project success or failure often results from lack of planning and ineffective control, causing inefficiency, delays, reduced quality, and cost overruns. Delays are detrimental to all parties regarding time and cost (*Armanda Putri & Gunasti, 2021*) (*Saputra et al., 2021*).

In construction, project control is one of the most vital management activities because poor management leads to significant irregularities in cost and time. To understand project performance beyond estimating completion time and cost, supervision, evaluation, and control of project time and costs are necessary (*Castollani et al., 2020*).

Construction project success depends on quality, time, and cost. Time control, or project scheduling, is essential for project completion. Good scheduling must be based on accurate time estimates, achievable using the Critical Path Method (CPM). CPM is the most widely used project planning and supervision method, utilizing network principles to optimize total project cost by reducing or accelerating project completion time (*Saputra et al., 2021*).

To avoid project losses, project completion time can be forecasted using the Value of Result Concept, a technique to measure project performance from a time aspect sustainably and estimate costs until project completion. Analysis results at each project evaluation provide information on project status and help managers make necessary decisions to improve project implementation to meet initial goals (*Andi Permana Sidiq, 2022*).

Contractors must manage construction projects systematically to ensure completion within contract time or sooner, so that costs yield profit and avoid fines due to delays. Therefore, acceleration is important to overcome delays. Acceleration is applied to critical activities, requiring creation of a project network, identification of critical activities, and duration calculation (*Yusuf Malif, 2019*).

Time management is an important factor affecting business success. It relates to how a person organizes activities to complete all tasks properly and on time. Time management is a method or tool to utilize and manage time effectively to carry out planned activities within a set period. Effective time management is key for managers, entrepreneurs, and small business owners seeking better work-life balance and business growth. Benefits include greater results in less time, improved focus and productivity, stress reduction, and more meaningful personal time (*Fitrani Dwi Azzahra & Marsella Putri Tommy Amanda, 2024*).

Time is irreplaceable; once passed, it cannot be regained. It is therefore a critical parameter in project success. Besides completion time, project duration greatly impacts overall cost. Project time management requires organizing reports (daily, weekly, monthly) to present work progress and compare actual completion to planned time, allowing verification. Construction projects face both expected and unforeseen obstacles causing project durations to often exceed allocated times, resulting in negative impacts. Delays mean increased completion time beyond contract plans. Although projects have schedules, discrepancies between plans and implementation often cause delays (*Vidia Pratiwi, 2024*).

The project budget plan calculates costs including materials, wages, and other direct and indirect costs associated with project implementation. This calculation must be precise and meet technical requirements. Costs vary across regions due to differences in material prices and labor wages (*Wiroso, 2023*).

Project costs are closely related to estimated budgets. Profit or loss in projects is highly dependent on planned cost management. Project cost management affects performance and impacts planned time. Construction duration is the length from start to project completion. Time scheduling arranges work sequences from start to finish, estimating total completion time. Time control ensures projects finish on or before planned times (*Andi Permana Sidiq, 2022*).

Time and cost are the main elements influencing project success. A project is successful if completed quickly at minimal cost without compromising quality. Hence, systematic and efficient management is required. Discrepancies often arise between schedules and actual execution, causing delays. To address this, project acceleration is necessary. Alternatives include increasing working hours (overtime), adding labor, using more productive equipment, faster-install materials, and quicker construction methods. Cost implications must be considered when choosing acceleration options (*Sofia et al., 2021*).

Cost control maintains consistency between planning and implementation, aiming to keep project costs within the budget. During feasibility and planning phases, cost control has the best chance of minimizing final costs. A plan addressing quality, volume, and unit price is necessary for cost control. Project schedule control monitors project activity status to determine progress, while cost control monitors expenditures during project execution. The main benefit is early recognition of cost or schedule deviations to enable corrective steps and minimize risk (*M. Jazuli, 2024*).

Because this project is a *Swakelola* project, construction is expected to be carried out efficiently with minimal cost. Therefore, this discussion focuses on accelerating time management through the Critical Path Method (CPM) and compares and evaluates previous project costs to avoid repetition in future projects. This allows the best proposals to be offered to agencies acting as project owners and managers. To shorten project duration at minimal cost, optimization is required. The first steps include creating a project network, calculating project duration, cost requirements, and resource needs. In this study, Microsoft Project software is used as a tool to process data, enabling good project progress control and completion on time with quality and cost accuracy. This research analyzes an acceleration plan by adding labor to the *Punging* river stonework construction in Mojokerto Regency.

This study aims to estimate the costs required for project acceleration by applying the Critical Path Method. The research is expected to provide strategic recommendations on time and cost management to improve construction project efficiency. The benefit for contractors is a reference for managing project implementation, enabling better project planning and analysis of construction delays applicable to other projects.

METHOD

This research was an applied study with an in-depth quantitative approach, aiming to analyze cost control in the construction of the Disaster Emergency Response Handling Project at the *Sungai Sumber Pasinan* in Mojokerto Regency, using the Critical Path Method (CPM). Project management theories and methods were applied to address practical issues related to project time and cost efficiency. The data consisted of primary and secondary sources. Primary data were obtained through direct observation at the project site to understand workflows and record activity durations and resource use via field notes and photo documentation. Secondary data were collected from literature, including books, scientific articles, lecture materials on project management, risk management, construction, and CPM methods, as well as project documents such as work schedules, progress reports, and time management records.

Data collection involved detailed field observations to document project activities, work durations, and relevant project records. The analysis proceeded through several stages, beginning with identifying and detailing project work data, including S-curves, weight, and volume. Next, work network analysis was performed using the CPM to identify activities on the critical path. Activities were sequenced based on logical dependencies with estimated durations. The analysis included calculating the Latest Event Time (LET) and Earliest Event Time (EET) to determine the critical path by assessing float times. Additionally, direct and indirect costs associated with project acceleration were calculated, and the optimal project duration was determined by comparing additional overtime costs with the resulting expenses.

This research aimed to provide strategic recommendations to improve time and cost efficiency in construction projects through the application of the Critical Path Method.

RESULTS AND DISCUSSION

Project Data

Project data is all the information related to a project that contains an overview of construction project planning. Project-related data or information can be divided into two, namely general project data and project technical data. General project data is identity data related to the project itself, while project technical data is data related to technical planning in the implementation of project development. Below you will find general project information and technical data for retaining wall construction projects. land with a pair of river stones in Sumber Pasinan, Mojokerto Regency.

Project Profile

The construction project of a pair of river stones in the Pungging River, Mojokerto Regency is a disaster response project aimed at anticipating the rise in the water level of the

Sumber Pasinan River which often overflows during the rainy season. If this problem is not addressed immediately, when the rainy season arrives, the riverbank can overflow and become more prevalent, causing landslides. The following details of the construction project of the Sumber Pasinan River stone pair, Mojokerto Regency, can be identified as follows:
Package Name : Handling Disaster Emergency Response
Location Project : Statue Village, Pugging District, Mojokerto Regency
Project Type : Swakelola
Source of Funds : DIPA Satker OP SDA Brantas
Start Work : 01 October 2024
End of Work : 21 December 2024
Implementation Time : 3 Months (71 Days)
Project Owner : ON SDA II BBWS Brantas
Planners : ON SDA II BBWS Brantas
Supervisor : ON SDA II BBWS Brantas
Implementing Contractor : ON SDA II BBWS Brantas
Job type : Batu Kali Couple
DPT Length : 45 m
DPT top width: 0.40 m
DPT Height : 6.00 m
Spacing between columns : 6.00 m
Distance between skurs : 6 m

Job Items

In the construction project of the Batu Sumber Pasinan Pair, Mojokerto Regency, there are several work items that include preparation work to finishing work. The following table 4.1 regarding the work items in the construction project of the Batu Kali Sumber Pasinan Pair, Mojokerto Regency.

Table 1. Work Items

No	Job Items
1	Prep Work
2	Earthworks
3	Structure Work
4	Couple Work
5	Piling Work
6	Miscellaneous Work

Source: Processed Researcher, 2024.

Work Break Down Structure

A tool in project management that organizes a list of project activities or goals according to its scope in a systematic manner. Based on the data from the plan's S curve contained in the appendix, the breakdown results and the code of each activity can be seen in table 4.2 below.

Tabel 2. Work Break Down Structure

No	Work Breakdown Structure	Code Activities
I	**Prep Work**	
1.1	Location Cleaning	A
II	**Earthworks**	
2.1	Ordinary Soil Excavation > 1 m to 2 m deep	B
2.2	Soil erosion returns	C
2.3	Work of a 50 kg sandbag pair	D
2.4	Ordinary Soil Excavation > 1 m to 2 m (manual)	Y
III	**Structure Work**	
3.1	Concrete mutu K175	F
3.2	Ironing with plain iron for ironing foundations, columns, and sloofs	G
3.3	Installation of foundation formwork and sloof	H
3.4	Column formwork installation	I
3.5	Beam Formwork Installation	J
IV	**Couple Work**	
4.1	Installation of Mixed Split Stone 1 SP : 4 PP	K
4.2	Flute pipe installation	L
4.4	Installation of Plastering 1 SP : 3 PP thickness 15 mm	M
4.5	1 m2 Acian Installation	N
5.6	Broadcast with 1PC:2PP	O
V	**Piling Work**	
5.1	Penetration of box concrete piles 20 x 20 cm deep 3 meters	P
YOU	**Other Jobs**	
6,1	Demolition Work	Q

Source: Processed Researcher, 2024.

Calculation of Duration of Work

Duration calculations typically consider several factors, such as the type of work, the volume of work, and the number of workers available. The coefficient of each work element and group of work performed manually or mechanically, with or without the use of heavy equipment.

a. List of Work Volume (*Bill Of Quantity*)

List of Volume Of Work (*Bill Of Quantity*) for the construction project of Batu Kali Sumber Pasinan Pair, Mojokerto Regency This list includes preparation work, dewatering work, earthworks, structural work, couple work, piling work. The following in table 4.3 is a list of the volume of work of the Batu Kali Sumber Pasinan Pair, Mojokerto Regency.

Table 3. List of Volume of Work (*Bill of Quantity*)

No	Job Name	Volume	Sat.
I	**PREPARATORY WORK**		
1.1	Location Cleaning	45,00	m2
II	**EARTHWORKS**		
2.1	Ordinary Soil Excavation > 1 m to 2 m deep	403,50	m3
2.2	Soil erosion returns	252,00	m3
2.3	Work of a 50 kg sandbag pair	599,00	bh
2.4	Ordinary Soil Excavation > 1 m to 2 m (manual)	40,00	m3
III	**STRUCTURAL WORK**		
3.1	Concrete mutu K175	16,52	m3
3.2	Ironing with plain iron for ironing foundations, columns, and sloofs	1.152,79	medical history
3.3	Installation of foundation formwork and sloof	49,40	m2
3.4	Column formwork installation	25,44	m2
3.5	Beam Formwork Installation	18,00	m2
IV	**SPOUSE WORK**		
4.1	Installation of Mixed Split Stone 1 SP : 4 PP	291,86	m3
4.2	Flute pipe installation	73,04	m1
4.4	Installation of Plastering 1 SP : 3 PP thickness 15 mm	53,40	m2
4.5	1 m2 Acian Installation	53,90	m2
4.6	Broadcast with 1PC:2PP	273,60	m2
V	**PILING WORK**		
5.1	Penetration of box concrete piles 20 x 20 cm 3 meters deep	48,00	m1
YOU	**OTHER JOBS**		
6,1	Demolition Work	180,00	m3

Source: Planner OP SDA II, 2024.

b. List of Workers and Tools

Based on observations in the field, it can be known the number of workers, and workers who are combined in a job and can also be identified as having work done manually or mechanically using heavy equipment at the time of implementation. In detail, it can be seen in the description below.

1) Site cleaning work

Preparation of land to be built with a pair of river stones

Type of job : Manual

Number of Workforce : 3 people

Number of tools : -

2) Ordinary Soil Excavation Work as deep as > 1 m to 2 m

Type of job : Mechanical

Number of Workforce: 2 people

Number of tools : 1 Excavator PC 120

3) Land management work returns

Type of job : Mechanical

Number of Workforce : 2 people

Number of tools : 1 Excavator PC 120

4) Installation work of 40 kg sandbag

Type of job : Manual

Number of Workforce: 4 people

Number of tools : -

5) Ordinary Soil Excavation Work > 1 m to 2 m (manual)

Type of job : Manual

Number of Workforce: 4 people

Number of tools : -

6) K175 quality Concrete Works

Type of job : Manual

Number of Workforce: 4 people

Number of tools : 1 piece of mill capacity 1 m3

7) Ironing work with plain iron for ironing foundations, columns and sloof

Type of job : Manual

Number of Workforce: 4 people

Number of tools : -

8) Foundation formwork and sloof

Type of job : Manual

Number of Workforce: 2 people

Number of tools : -

9) Column formwork work

Type of job : Manual

Number of Workforce: 2 people

Number of tools : -

10) Work on the Construction of the Bridge

Type of job :Manual

Number of Workforce: 2 people

Number of tools : -

11) Installation of 1 PC : 4 PP mixed split stone

Type of job :Manual

Number of Workforce: 6 people

Number of tools : -

12) Flute pipe installation

Type of job :Manual

Number of Workforce: 3 people

Number of tools : -

13) Plastering 1 PC : 3 PP 15 mm thick

Type of job :Manual
Number of Workforce: 4 people
Number of tools : -

14) Acian

Type of job :Manual
Number of Workforce: 4 people
Number of tools : -

15) Siaran 1 PC : 2 PP

Type of job :Manual
Number of Workforce: 2 people
Number of tools : -

16) Square concrete pile penetration 20 x 20 cm

Type of job :Mechanical
Number of Workforce: 2 people
Number of tools : 1 Excavator PC 120

17) Demolition Work

Type of job :Mechanical
Number of Workforce: 2
Number of tools : 1 Excavator PC 120

List of Job Coefficients

Based on the 2022 PUPR Ministerial Regulation, coefficient figures for manual and semi-mechanical work are obtained, while the tool coefficient figures are calculated based on productivity calculations in the 2022 PUPR Ministerial Regulation AHSP. In lump sump (LS) work, coefficients are not used because the work is follower and adjusted to the needs of the project. Based on the AHSP coefficient of work, it can be seen in table 4.4 below.

Table 4. List of Work Coefficients

No.	Job Description	Unit Index Coefficient (OH)	
		Workforce	Index
I	**Prep Work**		
1.1	Land preparation	Worker	0.112
		Carpenter	0.006
		Total	**0.118**
II	**Earthworks**		
2.1	Ordinary Soil Excavation > 1 m to 2m	Worker	0.188
		Total	**0.188**
2.2	Soil Erosion Returns	Worker	0.250
		Total	**0.250**
2.3	Work of a 50 kg sandbag pair	Worker	0.040
		Total	**0.040**
2.4	Ordinary Soil Excavation > 1 m to 2m (manual)	Worker	0,900
		Total	**0.900**
III	**Structure Work**		

No.	Job Description	Unit Index Coefficient (OH)	
		Workforce	Index
3.1	Concrete mutu K175	Worker	1.000
		Masons	0.250
		Total	**1.250**
3.2	Iron with plain iron for ironing foundations, columns and sloof	Worker	0.002
		Blacksmith	0.002
		Total	**0.004**
3.3	Foundation formwork and sloof	Worker	0.200
		Carpenter	0.100
		Total	**0.300**
3.4	Column formwork work	Worker	0.330
		Carpenter	0.330
		Total	**0.660**
3.5	Work on the Construction of the Bridge	Worker	0.360
		Carpenter	0.360
		Total	**0.720**
IV	**Pair Work**		
4.1	Installation of 1 PC : 4 PP mixed split stone	Worker	1.554
		Masons	0.676
		Total	**2.230**
4.2	2" flute pipe installation	Worker	0.100
		Total	**0.100**
4.3	Plastering 1 PC : 3 PP 15 mm thick	Worker	0.300
		Masons	0.150
		Total	**0.450**
4.4	Acian	Worker	0.200
		Masons	0.100
		Total	**0.300**
4.5	Siaran 1 PC : 2 PP	Worker	0.200
		Masons	0.200
		Total	**0.400**
V	**Piling Work**		
5.1	Penetration of box concrete piles 20 x 20 cm	Worker	0.150
		Total	**0.150**
YOU	**Miscellaneous Work**		
6.1	Demolition Work	Worker	**0**.400
		Total	**0.400**

Source: Processed Researcher, 2024.

Duration of Work

The sum of the labor coefficient is then multiplied by the volume and divided by 6 (effective hours in 1 day), so that the number of days is obtained as follows.

Table 4.5 List of calculations of work duration

No.	Job Description	Unit	Volume	Index (OH)	Number of Days
	a	b	c	d	(cxd)/6
I	**Prep Work**				
1.1	Location Cleaning	m2	45,00	0,018	0,89
II	**Earthworks**				
2.1	Ordinary Soil Excavation > 1 m to 2 m deep	m3	403,50	0,188	12,64
2.2	Soil erosion returns	m3	252,00	0,250	10,50
2.3	Work of a 50 kg sandbag pair	bh	599,00	0,040	3,99
2.4	Ordinary Soil Excavation > 1 m to 2 m (manual)	m3	40,00	0,900	6,00
III	**Structure Work**				
3.1	Concrete mutu K175	m3	16,52	1,250	3,44
3.2	Ironing with plain iron for ironing foundations, columns, and sloofs	medical history	1.152,79	0,004	0,77
3.3	Installation of foundation formwork and sloof	m2	49,40	0,300	2,47
3.4	Column formwork installation	m2	25,44	0,660	2,80
3.5	Beam Formwork Installation	m2	18,00	0,720	2,16
IV	**Pair Work**				
4.1	Installation of Mixed Split Stone 1 SP : 4 PP	m3	291,86	2,230	108,47
4.2	Flute pipe installation	m1	73,04	0,100	1,22
4.4	Installation of Plastering 1 SP : 3 PP thickness 15 mm	m2	53,40	0,450	4,01
4.5	1 m2 Acian Installation	m2	53,90	0,300	2,70
4.6	Broadcast with 1PC:2PP	m2	273,60	0,400	18,24
V	**Piling Work**				
5.1	Penetration of box concrete piles 20 x 20 cm 3 meters deep	m1	48,00	0,150	1,20
YOU	**Other Jobs**				
6,1	Demolition Work	m3	180,00	0,400	12,00

Source: Processed Researcher, 2024

Time Acceleration Calculation Using CPM *(Critical Path Method) Method*

In the calculation of time acceleration using the critical path method (CPM), the analysis of the overall time of the work item uses the calculation of the fastest time (early start) and the latest time (last start) and when the time for the longest work must be completed (lates finish). In addition, it is also the determination of the critical path, in this case activities that require extra attention or need to be prioritized, allocate resources more efficiently, and plan for time acceleration using the help of Microsoft Projects.

Determination of Dependency Logic (*Predecessor*)

Creating a network diagram requires determining the logical relationship of dependency between one activity and another in order to determine its predecessor. The following table 4.6 based on the results of the field study to determine the logical relationship of dependency (*predecessor*) is as follows.

Table 6. Determination of Dependency Logic (*Predecessor*)

Activity code	Job Description	*Predecessor*	Duration (days)	Number of Workers (people)
I	**PREPARATORY WORK**			
A	Location Cleaning		9	3
II	**EARTHWORKS**			
B	Ordinary Soil Excavation > 1 m to 2 m deep	A	8	2
C	Soil erosion returns	H	6	2
D	Work of a 50 kg sandbag pair	B	5	4
And	Ordinary Soil Excavation > 1 m to 2 m (manual)	A,B	7	4
III	**STRUCTURAL WORK**			
F	Concrete mutu K175	H,I,J	5	4
G	Ironing with plain iron for ironing foundations, columns, and sloofs	A	3	4
H	Installation of foundation formwork and sloof	G	8	2
I	Column formwork installation	H	4	2
J	Beam Formwork Installation	H	6	2
IV	**PAIR WORK**			
K	Installation of Mixed Split Stone 1 SP : 4 PP	G	53	6
L	Flute pipe installation	K	7	3
M	Installation of Plastering 1 SP : 3 PP thickness 15 mm	K	5	4
N	1 m2 Acian Installation	M	6	4
Or	Broadcast with 1PC:2PP	K	6	2
V	**PILING WORK**			
P	Penetration of box concrete piles 20 x 20 cm 3 meters deep	B	3	2
YOU	**OTHER JOBS**			
Q	Demolition Work	B	5	2

Source: Processed Researcher, 2024.

Project Activities and *Time Schedule*

The following are presented the activities carried out at the construction site of the Mojokerto river river rock pair, along with a time *schedule* chart of the progress plan targeted every week.

Planning project implementation schedule time using *microsoft project 2016*

The planned project planning schedule using *Microsoft Project 2016* is presented in the plan schedule bar chart and the *plan network schedule* diagram.

Based on the network schedule, the plan can be identified as work – that there are 8 jobs that are included in the critical track where if the work is 1 day late, it can cause delays in all work items. The jobs included in the *critical path* are shown in the following table 4.7.

Tabel 7. *Critical Task Schedule*

No.	Job Name
I	**Prep Work**
1.1	Location Cleaning
II	**Earthworks**
2.1	Ordinary Soil Excavation > 1 m to 2 m deep
IV	**Pair Work**
4.1	Installation of 1 PC : 4 PP mixed split stone
4.2	Installation of Plastering 1 SP : 3 PP thickness 15 mm
4.3	1 m2 Acian Installation
V	**Piling Work**
5.1	Penetration of box concrete piles 20 x 20 cm 3 meters deep

Source: Processed Researcher, 2024

Planning to accelerate project implementation schedule time using the S curve

Based on the planned S-curve, the construction project of the Batu Kali Sungai Sumber Pasinan is planned until October 2024, where there is a request to accelerate work due to the request of the Center (Center), so the project is accelerated to completion until the end of November 2024. Based on the project, it is planned to start in October 2024 to December 2024, but due to acceleration, projects that should be completed on December 21, 2024 are accelerated to be completed on November 23, 2024 or projects that are planned to take 71 working days, accelerated to 47 working days, with a difference in acceleration time of 24 days.

Calculation of project implementation schedule time acceleration using *microsoft project* 2016

The acceleration of the construction project of the stone pair this time was accelerated 24 days from the initial schedule, so there must be additional manpower for the work on the project, especially in locations with the highest workload. The biggest load on the construction of the stone pair this time is the assembly work of the kali stone pair, which is 70.16%. The addition of employees is calculated as:

<u>Number of workers at the work of the stone pair times</u>
Worker = 6 people
Length of work = 53 days
Length of work to be achieved = 30 days
So, the addition of workers is:

53 days x 6 people = 30 days x n

$n = \frac{53 \times 6}{30}$ = 10.6 people rounded up by 11 people

Based on the acceleration S curve in the discussion of table 4.8 and a brief calculation of the addition of workers to the installation of kali rock pairs, the following is a schedule bar diagram and a network diagram for the acceleration of the Sungai Sumber Pasinan Mojokerto kali rock pair work using *the Microsoft project*.

So the duration of the current work can be re-scheduled after the acceleration of time by adding workers to the installation work of the kali stone pair.

Table 8. Duration of Work After Acceleration with CPM

Activity code	Job Description	Duration (days)	Number of Workers (people)
I	**PREPARATORY WORK**		
A	Location Cleaning	9	3
II	**EARTHWORKS**		
B	Ordinary Soil Excavation > 1 m to 2 m deep	8	2
C	Soil erosion returns	6	2
D	Work of a 50 kg sandbag pair	5	4
Y	Ordinary Soil Excavation > 1 m to 2 m (manual)	7	4
III	**STRUCTURAL WORK**		
F	Concrete mutu K175	5	4
G	Ironing with plain iron for ironing foundations, columns, and sloofs	3	4
H	Installation of foundation formwork and sloof	8	2
I	Column formwork installation	4	2
J	Beam Formwork Installation	6	2
IV	**PAIR WORK**		
K	Installation of Mixed Split Stone 1 SP : 4 PP	30	6
L	Flute pipe installation	7	3
M	Installation of Plastering 1 SP : 3 PP thickness 15 mm	5	4
N	1 m2 Acian Installation	6	4
O	Broadcast with 1PC:2PP	6	2
V	**PILING WORK**		
P	Penetration of box concrete piles 20 x 20 cm 3 meters deep	3	2
Y	**OTHER JOBS**		
Q	Demolition Work	5	2

Source: Processed Researcher, 2024

Calculation of Cost Differences Due to Acceleration of Construction Work

Here is a comparison of the number of workers before and after the acceleration of construction work.

Table 9. Number of workers before and after work acceleration

Activity code	Job Description	Number of Workers Before Acceleration (people)	Number of Workers After Acceleration (people)
I	**PREPARATORY WORK**		
A	Location Cleaning	3	3
II	**EARTHWORKS**		
B	Ordinary Soil Excavation > 1 m to 2 m deep	2	2
C	Soil erosion returns	2	2
D	Work of a 50 kg sandbag pair	4	4
E	Ordinary Soil Excavation > 1 m to 2 m (manual)	4	4
III	**STRUCTURAL WORK**		
F	Concrete mutu K175	4	4
G	Ironing with plain iron for ironing foundations, columns, and sloofs	4	4
H	Installation of foundation formwork and sloof	2	2
I	Column formwork installation	2	2
J	Beam Formwork Installation	2	2
IV	**PAIR WORK**		
K	Installation of Mixed Split Stone 1 SP : 4 PP	6	11
L	Flute pipe installation	3	3
M	Installation of Plastering 1 SP : 3 PP thickness 15 mm	4	4
N	1 m2 Acian Installation	4	4
O	Broadcast with 1PC:2PP	2	2
V	**PILING WORK**		
P	Penetration of box concrete piles 20 x 20 cm 3 meters deep	2	2
Y	**OTHER JOBS**		
Q	Demolition Work	2	2

Source: Processed Researcher, 2024..

Cost slope *coefficient calculation*

The acceleration of the duration of the work was carried out by adding workers to the work with the highest volume, namely the installation of 1 PC: 4PP mixed split stone with a volume of 291.86 m3. The number of fixed working hours is 8 hours per day and 6 days per week. Based on the productivity of workers and the amount of work volume is calculated as follows.

<u>Mixed Split Stone Installation Work 1 PC : 4 PP</u>

(a) Volume of work = 291.86 m3
(b) Normal duration = 53 days
(c) Normal number of workers = 6 people
(d) Normal workers' wage costs = IDR 51,581,251.88
(e) Normal productivity $= \frac{(a)}{(b)}$
$= = 5.50$ m3$\frac{291,86}{53}$ / day.
(f) Worker productivity $= \frac{(e)}{(c)}$

= = 0.92 m3$\frac{5,5}{6}$ / day.

(g) Number of acceleration workers = 11 people

(h) Accelerated productivity = (f) x (g)

= 0,92 x 11 = 10,12 m3

(i) Acceleration aids = - (none)

(j) Acceleration duration = $\frac{(a)}{(h)}$

= = 28.84 days ~ 29 days $\frac{291,86}{10,12}$

(k) Additional fees = (j) x (g – c) x employee wages

= 29 x (11– 6) x IDR 113,700.00

= 29 x 5 x IDR 113,700.00

= IDR 16,486,500.00

(l) Acceleration costs = IDR 74,007,017,46 + IDR 16,486,500.00

= IDR 90,493,517.46

From the calculation above, the *cost slope* is obtained as follows.

Cost slope Installation of split stones = $\frac{(k)}{(b-j)}$

= $\frac{Rp\ 16.486.500,00}{(53-29)}$

= $\frac{Rp\ 16.486.500,00}{24}$

= IDR 686,937.50 /day

Table 1.0 Normalization, acceleration and *cost slope*

Job Description	Usual		Acceleration		*Cost Slope*
	Duration (Day)	Cost (Rp)	Duration (Day)	Cost (Rp)	
PREPARATORY WORK					
Location Cleaning	9	IDR511.650,00	9	IDR511.650,00	
EARTHWORKS					
Ordinary Soil Excavation > 1 m to 2 m deep	8	IDR8,625,054,60	8	IDR8,625,054,60	
Soil erosion returns	6	IDR7,163,100,00	6	IDR7,163,100,00	
Work of a 50 kg sandbag pair	5	IDR2,724,252,00	5	IDR2,724,252,00	
Ordinary Soil Excavation > 1 m to 2 m (manual)	7	IDR4,093,200,00	7	IDR4,093,200,00	
STRUCTURAL WORK					
Concrete mutu K175	5	IDR 2,347,336,50	5	IDR 2,347,336,50	
Ironing with plain iron for ironing foundations, columns, and sloofs	3	IDR419,430,78	3	IDR419,430,78	
Installation of foundation formwork and sloof	8	IDR1,685,034,00	8	IDR1,685,034,00	
Column formwork installation	4	IDR1,909,068,48	4	IDR1,909,068,48	

Job Description	Usual		Acceleration		*Cost Slope*
	Duration (Day)	Cost (Rp)	Duration (Day)	Cost (Rp)	
Beam Formwork Installation	6	IDR 1,473,552.00	6	IDR 1,473,552.00	
PAIR WORK					
Installation of Mixed Split Stone 1 SP : 4 PP	53	IDR74.007.017,46	30	IDR90,493,517,46	16.486.500,00
Flute pipe installation	7	IDR830,464,80	7	IDR830,464,80	
Installation of Plastering 1 SP : 3 PP thickness 15 mm	5	IDR2,732,211,00	5	IDR2,732,211,00	
1 m2 Acian Installation	6	IDR1,838,529,00	6	IDR1,838,529,00	
Broadcast with 1PC:2PP	6	IDR12,443,328,00	6	IDR12,443,328,00	
PILING WORK					
Penetration of box concrete piles 20 x 20 cm 3 meters deep	3	IDR818.640,00	3	IDR818.640,00	
OTHER JOBS					
Demolition Work	5	IDR8,186,400,00	5	IDR8,186,400,00	

Source: Processed Author, 2024.

Based on the results of the calculations that have been carried out, the normal time of the split stone pair work is 53 days with a total cost of IDR 74,007,017.46. So that the acceleration was carried out from the initial duration to 30 days for the work of split stone pairs with a total cost of IDR 90,493,517.46 so that a total *cost slope* of IDR 16,486,500.00 was obtained.

CONCLUSION

Based on the analysis, accelerating the construction of the split stone pair project at the *Sumber Pasinan* River using the Critical Path Method (CPM) successfully reduced the project duration from 71 to 47 working days, achieving a 24-day acceleration. This time reduction required adding 11 workers for the split stone installation but led to an increased labor cost of Rp16,486,500.00 beyond the original budget. These results demonstrate that the CPM method effectively optimizes project timelines, though careful cost budget adjustments are necessary to accommodate acceleration expenses. Future research could explore balancing workforce additions and cost increases by investigating alternative acceleration strategies or integrating resource optimization models alongside CPM to enhance both time and cost efficiency.

REFERENCES

Anakta Sebayang, R. O. W. (2022). *Analysis of Slope Safety Factors Against Trikora Road Avalanche with Soil Retaining Wall Handling*.

Andi, M., Putra, M., & Witjaksana, B. (2023). *Analysis of Acceleration of Structural Work Time Using the CPM Method in the 57 Nganjuk Hotel Construction Project*. *7*(2), 118–125. https://ejournal.itn.ac.id/index.php/sondir

Andi Marini Indriani, G. U. M. R. (2022). Analysis of the time and cost performance of construction projects using the Earned Value Analysis method. *Journal of Geoeconomics*, *13*(2), 128–137. https://doi.org/10.36277/geoekonomi.v13i2.219

Andi Permana Sidiq, G. J. J. (2022). *Analysis of the Application of Earned Value to Time and Cost Management in the Cibani Bridge Project*. https://jurnal.itg.ac.id/

Castollani, A., Puro, S., Maiko, *, & Dewa, L. (2020). *Cost and Time Analysis in Apartment Projects Using the Earned Value Concept Method*. *3*(1).

Chen, A. Y., Peña-Mora, F., & Ouyang, Y. (2011). A collaborative GIS framework to support equipment distribution for civil engineering disaster response operations. *Automation in Construction*, *20*(5), 637–648.

This is Ayu Putu Sri Mahapatni. (2019). *Construction Project Planning and Control Methods*.

M. Jazuli, R. R. D. (2024). Cost and Time Analysis on Bridge Projects (Case Study of Candisari Sambeng Bridge Construction Project, Lamongan Regency) Using the Earned Value Method. Journal of Civic Talent, 7(1), 73. https://doi.org/10.33087/talentasipil.v7i1.376

Mutia Astari, N., & Momon Subagyo, A. (2021). Project management planning using the CPM (Critical Path Method) and Pert (Program Evaluation and Review Technique) methods. In the Journal of Construction | (Vol. 13).

Nazilah P. Abas, T. P. F. S. A. S. S. R. (2022). Analysis of Implementation Time and Cost Using CPM Method and Crashing Method in the North Sulawesi Police Forensic Laboratory Construction Project.

Perrucci, D. V, Wilson, J., Brown, R., Mireles Camey, J., Doktycz, C., Perry, M., & Buitrago, G. C. (2025). Using the critical path method (CPM) for evaluating allocation potential of temporary housing units. *Journal of Housing and the Built Environment*, 1–13.

Priyanto, E., Ervadius, B., & Wahyudi, M. A. (2019). Acceleration of time and cost for the planning of the Steam Turbine Building Fabrication Project in Block 2 Muara Tawar using the CPM method.

Saputro, A., Yakin, K., & Octaviani, M. (2023). Analysis of project acceleration and its impact on time and cost using the Critical Path method

Sofia, D. A., Aulia, A., & Putri, E. (2021). Comparative Analysis of Increase in Working Hours and Labor to Project Time and Cost with the Time Cost Trade Off Method.

Supratikno, S. A. M. A. G. (2023). Comparative Study of the Price of Renovation of 200-meter Talud with Pair of Face Stones and Concrete Slabs with Wiremesh Reinforcement. 11(1). https://doi.org/10.21063/JTS.2024.V1101.077-82

Vidia Pratiwi, A. A. (2024). Comparative Analysis of Plan Time Management with the Actual Condition of the XYZ Campus Building Construction Project.

Wang, C.-P., Shih, B.-J., & Liaw, S.-J. (2021). Prehospital scheduling management by the critical path method for burn mass casualty incidents. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, *58*, 00469580211028583.

Wiroso, L. H. (2023). Comparison of the Installation Index of Kali Stone Foundations Using Analysis of Work Unit Prices and Actual Conditions (Case Study of the Construction of Gladagsari District Office, Boyolali Regency).

Yaqin, H. N., Tjendani, H. T., & Witjaksana, B. (2023). Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method. *Devotion: Journal of Research and Community Service*, *4*(2), 336–346.

Yusuf Malif, A. K. T. D. Y. M. (2019). Analysis of the acceleration of construction project time and cost using the crashing method (Case Study: Construction of Iain Manado

Flats). Journal of Static Civility, 7 (June), 681–688.