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Cost Analysis Required for the Construction of the Banjarsari Sluice Project, Sidoarjo Regency

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Abstract

The Banjarsari sluice on the *Sungai Pengairan* in Sidoarjo Regency faces performance challenges, including sedimentation, structural damage, and water quality degradation from waste. The maintenance project prioritizes repairing the leaking floor to prevent structural failure. To optimize scheduling, the Critical Path Method (CPM) is recommended, enabling precise calculation of project start and end times as well as activity durations. Thus, we can determine the *time lag* between all existing activities. The analysis of the acceleration of work duration is also carried out by increasing the number of workers on the critical path, as well as finding the best solution to achieve the most efficient cost. The purpose of this study is to determine the amount of cost required by the Banjarsari *Pintu Air* maintenance project. In this study, the analysis was carried out using the CPM method and supported by Microsoft Project 2021 software. The results of the analysis show that the total cost for work on the critical path is Rp 117,732,707, which increased to Rp 124,366,707, resulting in a cost difference of Rp 6,634,000. The study concludes that while acceleration strategies increase costs, they effectively reduce project duration, ensuring timely completion. The findings underscore the importance of systematic planning and resource management in construction projects.

Keywords: Schedule, Cost, CPM, Microsoft Project

INTRODUCTION

Construction projects are inherently complex and are often challenged by delays and cost overruns. Effective construction project management is crucial to optimize efficiency and effectiveness throughout the project lifecycle. A key component of this management is **project control estimation**, which systematically sets standards aligned with project goals, designs information systems to monitor progress, and analyzes deviations. This enables timely corrective actions to ensure resources are efficiently used and project objectives are met (Pradita et al., 2023).

Delays are frequently caused by various factors, with human resource shortages being a predominant issue impacting activities such as foundation casting, beams, and floors (Thaariq, n.d., 2024). Since construction projects consist of interrelated activities that must be sequentially completed, contractors must develop robust strategies to prevent delays and, ideally, complete projects ahead of schedule.

Deviation from initial project plans often affects schedule, cost, and quality. This underscores the critical need for effective project management covering all stages—planning, organizing, implementing, supervising, and maintaining—to minimize disruptions and deliver projects on time, within budget, and meeting quality standards (Eliana, 2021).

Time management, particularly scheduling, significantly influences project success. Timely project completion with cost efficiency and maintained quality requires careful schedule management since delays can lead to cost overruns (Tamalika and Fuad, n.d., 2020).

Cost is a pivotal factor in construction projects. Cost overruns frequently indicate project failures and call for attention to early identification of risks and strategic planning to mitigate such risks. Factors causing cost overruns vary by country and industry context, emphasizing the need for tailored management approaches (Thérèse et al., n.d., 2020). Effective cost management plans aligned with a company's business model are indispensable for smooth project execution (Uda et al., n.d., 2021).

The **Critical Path Method (CPM)** is a foundational tool in construction project planning, providing data-driven scheduling. CPM identifies the longest sequence of dependent activities determining the project's shortest completion time. Key concepts include Early Start (ES), Early Finish (EF), Late Start (LS), and Late Finish (LF), derived from forward and backward pass calculations to determine flexibility or float in activities (Nugraha, 2020 in Wijaya et al., n.d., 2021).

Critical activities have zero float and any delay directly impacts the project duration, whereas non-critical activities have some scheduling flexibility. CPM incorporates activity constraints such as Finish-to-Start (FS) and Start-to-Start (SS), and lag time to reflect realistic workflows (Kiswati & Chasanah, 2019; Nasrul, 2015; Rama Auliansyah et al., 2023; Yudhistira et al., 2023a, 2023b).

Crashing is an analytical method focused on shortening critical path activities by adding resources such as labor or overtime to accelerate project completion, albeit at increased costs. This tradeoff between time and cost is managed to optimize project duration without sacrificing efficiency (Sa'adah et al., n.d.).

Labor productivity, essential for scheduling and estimating costs, is the output per worker per time unit. Overtime is used as a means to enhance productivity by extending work hours beyond the normal 8-hour day (Balqis & Sugiono, 2020; Entayani Upasuji & Satrya, 2020; Saefullah, 2021).

The *Banjarsari* sluice gate, located on the *Sungai Pengairan* (Shipping River) in Sidoarjo Regency, is vital infrastructure for regulating water flow, supporting irrigation, flood control, and supplying raw water to the Drinking Water Treatment Plant (IPAM). This facilitates agricultural productivity and regional economic growth.

Challenges in the sluice gate's performance include sedimentation, structural damage from seepage floors, and water quality degradation due to waste. The maintenance project focuses on repairing the leaking floors to prevent structural failures, ensuring the sluice continues to fulfill its critical roles (Nurhidayati et al., 2023; Sugiyono, 2016).

Delays in the sluice gate project were mainly due to foundation casting failures linked to a leaking *kitsdam* (dewatering system), which led to water intrusion during concrete casting. Additionally, controlling upstream water discharge was complicated by simultaneous needs for irrigation and IPAM water demands. These factors extended the project timeline and required rework (Field Supervisor Interviews, 2024).

The research conducted applied CPM using Microsoft Project software to analyze and optimize the maintenance project's schedule and costs. The project aimed for completion in 30 calendar days, with the goal of minimizing delays and cost overruns through crashing techniques by either adding workers or implementing overtime.

By comparing schedules and costs before and after optimization, the study aimed to identify potential efficiency improvements and provide recommendations for future project management enhancements. This approach helps service providers prioritize activities that critically impact project completion within the *Banjarsari* Water Gate maintenance project (Study Objective, 2024).

METHOD

This study applied a descriptive approach to systematically describe the conditions of the Banjarsari Water Gate Construction project in *Sungai Pelayaran*, Sidoarjo Regency, with a focus on project cost analysis using the Critical Path Method (CPM). The data consisted of qualitative and quantitative types. Qualitative data included information on dependency relationships between project activities and factors causing delays, obtained through interviews, observations, and literature review. Quantitative data comprised measurements of time, cost, and labor volume taken from project documents such as work drawings, schedules, and unit price analysis (AHS), supplemented by field observations.

Primary data were collected through interviews with field workers and company staff, along with direct observation of project activities. Secondary data were sourced from project documents and regulations, including the 2023 Regulation of the Minister of Public Works and Public Housing. Data collection techniques included interviews, observations, and literature studies to ensure relevant and accurate information for analysis.

For data analysis, the researcher obtained project work drawings, schedules, and Unit Price Analysis (AHS) from the Brantas River Regional Center. Project activities were inventoried and broken down into detailed components, then coded. Duration and cost calculations were based on field data and unit prices. Dependency relationships between activities were determined through interviews and observations. Time calculations employed the Earliest Event Time (EET) and Latest Event Time (LET) methods with Microsoft Project 2021 software. The researcher developed the project network using CPM and calculated total project costs from the collected data. Critical paths were identified, and activities on these paths were accelerated if necessary to optimize completion time.

This study aimed to provide insights on scheduling efficiency and cost management and to offer recommendations for improving future project management.

RESULTS AND DISCUSSION

Cost Analysis Using the *Critical Path Method*

The cost analysis due to delays in sluice work using *the Critical Path Method* (CPM) method aims to evaluate the financial impact resulting from delays in the project. CPM helps identify critical paths, which are the set of activities that determine the overall project completion time. Delays in any of the activities on the critical track will affect the total duration of the project. This delay can incur additional costs, both in the form of direct costs such as workers' wages and indirect costs such as contract fines or economic losses.

Cost Budget Plan

A Cost Budget Plan (RAB) is an important document in project implementation that aims to detail and estimate cost needs in detail and systematically. This document is prepared to ensure that all project needs, whether material resources, labor, and other operational costs, can be properly accommodated. The cost budget plan for the construction of the Banjarsari sluice project can be seen in table 1. The following :

Table 1. Cost Budget Plan

No.	Job Description	Sum Price
I	***PREPARATORY WORK***	
1.1	Measurement / Bouwplank	IDR 2,395,404
	Total:	**IDR 2,395,404**
II	***DEMOLITION WORK***	
2.1	Existing Concrete Demolition	IDR 1,501,465
2.2	Stone Pair Dismantling	IDR 573,023
2.3	Concrete Demolition of Existing Cyclloop	IDR 16,286,062
2.4	Dismantling of secondary sluices	IDR 7,846,968
	Total:	**Rp.26.602.923**
III	***DEWATERING WORK***	
3.1	Soil kistdam work	IDR 6,753,024
3.2	Bamboo Retaining Job	IDR 3,746,476

Source: Processed Researcher, 2024

Table 2. Cost Budget Plan (advanced)

No.	Job Description	Sum Price
3.3	Bamboo Stub Retaining Frame Work	IDR 2,047,778
3.4	Hourly operation of the water pump	IDR 50,584,641
3.5	Dismantling of the kistdam	IDR 327,456
	Total:	**IDR 63,459,376**
IV	***STRUCTURAL WORK***	
4.1	Quality Concrete K175	IDR 6,179,815
4.2	K125 Quality Concrete (Concrete Rebate)	IDR 2,040,211
4.3	Ironing with plain iron	IDR 10,597,688
4.4	Concrete Sikoop Flooring	IDR 91,525,188
4.5	Installation of foundation formwork and sloof	IDR 881,862
4.6	Installation of beam formwork and beam ring	IDR 422,709
4.7	Installation of column formwork	IDR 471,549
4.8	Mounting of plate formwork	IDR 1,645,483
4.9	Ironing wiremesh	IDR 206,606
	Total:	**IDR 113,971,116**
V	***INSTALLATION WORK***	
5.1	Installation of mixed split stones 1 SP : 4 PP	IDR 17,847,826
5.2	Installation of mixed raen stone 1 SP : 4 SP	IDR 6,639,235
5.3	Installation of stucco 1 SP : 3 PP thickness 15 mm	IDR 752,290
5.4	Installation of acian	IDR 1,323,950
5.5	Broadcast with 1PC:2PP	IDR 5,964,025
	Total:	**IDR 32,527,328**
VI	***ROOFING WORK***	
6.1	Procurement and installation of roof trusses	IDR 6,382,039
6.2	Procurement and installation of spandex roof covers	IDR 17,321,451
	Total:	**IDR 23,703,491**
VII	***PAINTING WORK***	
7.1	Secondary sluice gate painting	IDR 3,798,622
7.3	Painting columns, beams and beam rings	IDR 1,198,953
	Total:	**IDR 4,997,576**

Source: Processed Researcher, 2024

Table 3. Cost Budget Plan (advanced)

No.	Job Description	Sum Price
	Total:	**IDR 4,997,576**
VIII	***SLUICE WORK***	
8.1	Modification and installation work of existing secondary sluices	IDR 106,574,406
8.2	Construction and installation work of a new secondary sluice gate	IDR 164,183,406
	Total:	**IDR 270,757,812**
IX	***MISCELLANEOUS WORK***	
9.1	Procurement and installation of BRC fence	IDR 1,292,695
	Total:	**IDR 1,292,695**
	Grand Total:	**IDR 539,312,319**
	Rounding	**IDR 539,313,000**

Source: Processed Researcher, 2024

Cost analysis based on CPM method critical paths with *Microsoft Project 2021*

Cost analysis using the Critical Path Method (CPM) with the help of Microsoft Project is a technique to determine the activities that most affect the total duration of the project and optimize the use of resources. In this method, the project cost is calculated by integrating the estimated budget for each activity, so that the total cost for the critical path can be known. This analysis aims to identify activities that directly affect the project completion schedule, so that cost management can be more focused on those critical activities.

The following are the jobs that are on the critical path according to calculations using Microsoft Project can be seen in table 4:

Table 4. Critical Path Cost Analysis

No.	Job Description	Duration of work (Day)	Total Price (Rp)
II	***DEMOLITION WORK***		
2.1	Existing Concrete Demolition	6	IDR 1,501,465
2.2	Stone Pair Dismantling	3	IDR 573,023
2.3	Concrete Demolition of Existing Cyclloop	10	IDR 16,286,062
2.4	Dismantling of Existing Sluices	3	IDR 7,846,968
IV	***STRUCTURAL WORK***		
4.1	Concrete Sikoop Flooring	12	IDR 91,525,188
	Total Cost Amount		**Rp.117.732.707**

Source: Processed Researcher, 2024

Based on figure 4, it can be identified that there is a significant difference between the planned schedule (*time schedule*) and the realization of work in the field. This difference is caused by delays in the demolition work which has a direct impact on the implementation of other construction activities. The delay in this work was caused by the dewatering section being broken by the impact of the demolition work and the cyclic work could not be carried out with the pre-planned time.

The following is the difference between plans and realizations that occur in the field can be seen in table 5. The following :

Table 5. Progress of Water Gate Work Week 3

No	Description	Cumulative weight
1	Initial plan	16,74%
2	Realization	16,49%
3	Deviation	-0,25%

Source : Processed Author , 2024

Alternative Analysis of Time and Cost Due to Time Delay

The alternative analysis of time and costs due to time delays in sluice projects is an evaluation process that aims to identify the impact of delays on the achievement of project targets and propose solutions to minimize their consequences. Delays in sluice gate construction projects can be caused by various factors, such as technical problems, lack of coordination, unfavorable weather, and material constraints. The impact of these delays not only affects the project schedule but also increases costs, including direct costs (such as additional labor wages and equipment costs) as well as indirect costs (such as penalties or claims from other parties).

In this analysis, *the Critical Path Method* (CPM) method is often used to identify critical paths in the project schedule and determine acceleration alternatives such as increased working hours (overtime), use of additional resources, or changes in work methods.

Time Analysis by Adding the Number of Workers to Items in the Critical Line

The first alternative, namely by increasing the number of workers on items on the critical line, is a strategy to accelerate the completion of the sluice gate project that has been delayed due to demolition work and also the concrete casting of cycloquins. This approach is carried out by adding manpower to activities that are on a critical path, namely a series of jobs that determine the total duration of the project. The addition of the workforce allows the activity to be completed faster without changing the order of other jobs.

Here is in table 6. It shows the number of workers on work items that are in the critical path.

Table 6. Duration and number of workers on critical line work

No.	Job Description	Number of employees	Duration of work
II	***DEMOLITION WORK***		**16**
2.1	Existing Concrete Demolition	4	6
2.2	Stone Pair Dismantling	3	6
2.3	Concrete Demolition of Existing Cyclloop	4	10
2.4	Dismantling of Existing Sluices	3	5
IV	***STRUCTURAL WORK***		
4.1	Concrete Sikoop Flooring	6	12

Source: Processed Researcher, 2024

Because of the delay in this work, it is necessary to accelerate each work. Here are the work items that are on a critical path. The longest work weight is on the critical track. The addition of workers at the Banjarsari sluice gate in Sidoarjo Regency is calculated as follows:

- **Number of Workers in Existing Concrete Demolition Work**
  Worker = 4 people
  Length of work = 6 days
  Length of work to be achieved = 4 days
  So, the addition of workers is:
  6 days x 4 people = 24 people x *n*
  $n = \frac{6 \, x \, 4}{4}$ = 6 people
  Addition of employees = 6 – 4 = 2 people
- **Number of Workers at the Stone Pair Demolition Work**
  Worker = 3 people
  Length of work = 6 days
  The length of work to be achieved = 4 days
  So, the addition of workers is:
  6 days x 3 people = 18 people x *n*
  $n = \frac{6 \, x3}{4}$ = 4.5 people ~ 5 people
  Increase of employees = 6 – 5 = 1 person
- **Number of Workers at the Existing Cyclloop Concrete Demolition Work**
  Worker = 4 people
  Length of work = 10 days
  The length of work to be achieved = 7 days
  So, the addition of workers is:

10 days x 3 people = 30 people x n
$n = \frac{10 \; x \; 4}{7}$ = 5.71 people ~ 6 people
Addition of employees = 6 – 4 = 2 people

- **Number of Workers in Existing Sluice Gate Dismantling Work**
  Worker = 3 people
  Length of work = 5 days
  The length of work to be achieved = 3 days
  So, the addition of workers is:
  5 days x 3 people = 15 people x n
  $n = \frac{5 \; x \; 3}{3}$ = 5 people
  Addition of employees = 5 – 3 = 2 people
- **Number of Workers on Concrete Cyclloop Floor Work**
  Worker = 6 people
  Length of work = 12 days
  The length of work to be achieved = 9 days
  So, the addition of workers is:
  12 days x 6 people = 6 people x n
  $n = \frac{12 \; x \; 6}{9}$ = 8 people
  Increase of employees = 8 – 6 = 2 people

i. Cost analysis by adding the number of workers on Items in the critical line

The cost analysis of adding workers to items in critical lines aims to speed up project completion without exceeding the planned deadline. In this method, the focus is given to activities that are on a critical track because delays in this track will directly affect the total duration of the project. Adding workers is usually done by considering the *crashing cost* and the potential for time reduction.

a. Calculation of *Employee Cost Slope*

The acceleration of the duration of work is carried out by adding workers to work in the critical line. 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.

- **Number of Workers in Existing Concrete Demolition Work**

(a) Volume of work = 10.20 m^3
(b) Normal duration = 6 days
(c) Normal number of workers = 4 people
(d) Normal workers' wage costs = IDR 47,823,000
(e) Normal productivity $= \frac{(a)}{(b)}$
==1.7~2 m^3/day$\frac{10{,}20 \; m^3}{6 \; hari}$
(f) Worker productivity $= \frac{(e)}{(c)}$
= = 0.5 m^3 / day$\frac{2}{4}$
(g) Number of additional employees = 6 people
(h) Worker productivity = (f) x (g)
= 0.5 x 6 = 3 m^3
(i) Target duration = 4 days
(j) Additional fees = (i) x (g-c) x employee wages
= 4 (6-4) x IDR 113,700
= 4 x (2) x IDR 113,700

= IDR 909,600
(k) Total cost = IDR 47,823,000 + IDR 909,600
= IDR 48,732,600

From the calculation above, the cost slope is obtained as follows:
Cost slope of existing concrete demolition work
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.909.600}{6-4}$
$= \frac{Rp.909.600}{2}$
= IDR 454,800

- **Number of Workers on the Stone Couple Dismantling Job**
- Volume of work =3.55 m³
- Normal duration = 6 days
- Normal number of workers = 3 people
- Normal workers' wage costs = IDR 47,823,000
- Normal productivity $= \frac{(a)}{(b)}$

==0.59~1 m³/day$\frac{3,55\ m^3}{6\ hari}$
- Worker productivity $= \frac{(e)}{(c)}$

= = 0.33 m³ / day$\frac{1}{3}$
- Number of additional employees = 5 people
- Worker productivity = (f) x (g)
  = 0.33 x 1 = 0.33 m³
- Target duration = 4 days
- Additional fees = (i) x (g-c) x employee wages
  = 4 x (5-3) x IDR 113,700
  = 4 x (2) x IDR 113,700
  = IDR 909,600
- Total cost = IDR 47,823,000 + IDR 909,600
  = IDR 48,732,600

From the calculation above, the cost slope is obtained as follows:
Cost slope stone couple dismantling work
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.909.600}{6-4}$
$= \frac{Rp.909.600}{2}$
= IDR 454,800

- **Number of Workers at Sikloop Concrete Demolition Work**

(a) Volume of work = 37.50 m³
(b) Normal duration = 10 days
(c) Normal number of workers = 4 people
(d) Normal workers' wage costs = IDR 47,823,000
(e) Normal productivity $= \frac{(a)}{(b)}$

==3.75~4 m³/day$\frac{37,50\ m^3}{10\ hari}$

(f) Worker productivity = $\frac{(e)}{(c)}$
= = 1 m³ / day$\frac{4}{4}$
(g) Number of additional employees = 6 people
(h) Worker productivity = (f) x (g)
= 1 x 6 = 6 m³
(i) Target duration = 7 days
(j) Additional fees = (i) x (g-c) x employee wages
= 7 x (6-4) x IDR 113,700
= 7 x (2) x IDR 113,700
= IDR 1,591,800
k. Total cost = IDR 47,823,000 + IDR 1,591,800
= IDR 49,414,800
From the calculation above, the cost slope is obtained as follows:
Cost slope concrete demolition work cyclloop
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.1.591.800}{10-7}$
$= \frac{Rp.1.591.800}{3}$
= IDR 530,600

- **Number of Workers in Existing Sluice Gate Dismantling Work**

(a) Volume of work = 4 m³
(b) Normal duration = 5 days
(c) Normal number of workers = 3 people
(d) Normal workers' wage costs = IDR 47,823,000
(e) Normal productivity = $\frac{(a)}{(b)}$
==3.75~4 m³/day$\frac{37,50\ m^3}{10\ hari}$
(f) Worker productivity = $\frac{(e)}{(c)}$
= = 1 m³ / day$\frac{4}{4}$
(g) Number of additional employees = 5 people
(h) Worker productivity = (f) x (g)
= 1 x 5 = 5 m³
(i) Target duration = 3 days
(j) Additional fees = (i) x (g-c) x employee wages
= 3 x (5-3) x IDR 113,700
= 7 x (1) x IDR 113,700
= IDR 1,023,300
(k) Total cost = IDR 47,823,000 + IDR 1,203,300
= IDR 49,026,300
From the calculation above, the cost slope is obtained as follows:
Cost slope of sluice gate dismantling work
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.1.023.300}{5-3}$
$= \frac{Rp.1.023.300}{2}$
= IDR 511,650

- **Number of Workers on Concrete Cyclloop Floor Work**

(a) Volume of work = 81.37 m³
(b) Normal duration = 12 days
(c) Normal number of workers = 6 people
(d) Normal workers' wage costs = IDR 47,823,000
(e) Normal productivity = $\frac{(a)}{(b)}$
==6.78~7 m³/day$\frac{81{,}37\ m^3}{12\ days}$
(f) Worker productivity = $\frac{(e)}{(c)}$
= = 1.16 m³ / day$\frac{7}{6}$
(g) Number of additional employees = 8 people
(h) Worker productivity = (f) x (g)
= 1.16 x 8 = 9.8 m³
(i) Target duration = 9 days
(j) Additional fees = (i) x (g-c) x employee wages
= 9 x (8-6) x IDR 113,700
= 9 x (2) x IDR 113,700
= IDR 2,046,600
(k) Total cost = IDR 47,823,000 + IDR 2,046,600
= IDR 49,869,600
From the calculation above, the cost slope is obtained as follows:
Cost slope concrete demolition work cycle floor
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.2.046.600}{12-9}$
$= \frac{Rp.2.046.600}{3}$
= IDR 682,200

b. Cost Slope *Calculation Tool*

- **Number of Tools on Existing Concrete Demolition Work**

(a) Volume of work = 10.20 m³
(b) Normal duration = 6 days
(c) Normal number of tools = 2 pieces
(d) Normal tool cost = IDR 1,153,125
(e) Productivity = $\frac{(a)}{(b)}$
==1.7~2 m³/day$\frac{10{,}20\ m^3}{6\ hari}$
(f) Tool productivity = $\frac{(e)}{(c)}$
= = 0.5 m³ / day$\frac{2}{4}$
(g) Number of tools = 4 pieces
(h) Tool productivity = (f) x (g)
= 0.5 x 4 = 2 m³
(i) Target duration = 4 days
(j) Additional fees = (i) x (g-c) x appliance rental cost
= 4 (4-2) x IDR 450,000
= 4 x (2) x IDR 450,000
= IDR 3,600,000
(k) Total cost = IDR 1,153,125 + IDR 3,600,000

= IDR 4,753,125
From the calculation above, the *cost slope* is obtained as follows:
Cost slope of existing concrete demolition work
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.3.600.000}{6-4}$
$= \frac{Rp.3.600.000}{2}$
= IDR 1,800,000

- **Number of Workers On the Stone Couple Dismantling Job**

a. Volume of work =3.55 m³
b. Normal duration = 6 days
c. Normal number of tools = 1 piece
d. Normal tool cost = IDR 1,153,125
e. Normal productivity $= \frac{(a)}{(b)}$
==0.59~1 m³/day$\frac{3{,}55\ m^3}{6\ days}$
f. Productivity $= \frac{(e)}{(c)}$
= = 0.33 m³ / day$\frac{1}{3}$
g. Additional number of tools = 2 tools
h. Worker productivity = (f) x (g)
= 0.33 x 2 = 0.66 m³
i. Target duration = 4 days
j. Additional fees = (i) x (g-c) x appliance rental cost
= 4 x (2-1) x IDR 450,000
= 4 x (1) x IDR 450,000
= IDR 1,800,000
k. Total cost = IDR 1,153,125+ IDR 1,800,000
= IDR 2,953,125

From the calculation above, the cost slope is obtained as follows:
Cost slope stone couple dismantling work
$= \frac{(j)}{(b-i)}$
$= \frac{Rp.1.800.000}{6-4}$
$= \frac{Rp.1.800.000}{2}$
= IDR 900,000

- **Number of Workers On the Stone Couple Dismantling Job**

a. Volume of work =37.50 m³
b. Normal duration = 10 days
c. Normal number of tools = 2 pieces
d. Normal tool cost = IDR 1,153,125
e. Normal productivity $= \frac{(a)}{(b)}$
= = 1,775 m³ / day$\frac{3{,}55\ m^3}{2\ days}$
f. Productivity $= \frac{(e)}{(c)}$

= = 0.88 m³ / day$\frac{1,775}{2}$

g. Additional number of tools = 4 tools

h. Worker productivity = (f) x (g)
= 0.88 x 4 = 3.52 m³

i. Target duration = 4 days

j. Additional fees = (i) x (g-c) x appliance rental cost
= 4 x (4-2) x IDR 450,000
= 4 x (2) x IDR 450,000
= IDR 3,600,000

k. Total cost = IDR 1,153,125 + IDR 3,600,000
= IDR 4,753,125

From the calculation above, the *cost slope* is obtained as follows:
Cost slope stone couple dismantling work

$= \frac{(j)}{(b-i)}$

$= \frac{Rp.3.600.000}{10-4}$

$= \frac{Rp.1.800.000}{6}$

= IDR 300,000

The additional costs were made to speed up the completion of the work, which had an impact on the increase in costs compared to the original plan. The following shows the total *cost slope* and initial plan costs which show an increase in costs due to the addition of workers in the Banjarsari sluice project.

CONCLUSION

The analysis of the Banjarsari Water Gate Construction project on *Sungai Pelayaran*, Sidoarjo Regency, using the Critical Path Method (CPM), revealed that adding workers along the critical path increased the total cost to Rp 117,732,707, and with the further addition of equipment rental, the cost rose to Rp 124,366,707. By accelerating the project duration through workforce increases and rescheduling via Microsoft Project 2019, the project completion time was reduced from 72 to 66 working days. However, this time reduction came with an added cost of Rp 6,634,000. Future research could explore optimizing the balance between cost and time by investigating alternative acceleration strategies, incorporating resource leveling, or applying more advanced project management software to further improve efficiency and cost-effectiveness.

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