INTERNATIONAL JOURNAL ON ADVANCED TECHNOLOGY, ENGINEERING, AND INFORMATION SYSTEM (IJATEIS)

COST AND TIME ANALYSIS USING THE CRASHING METHOD ON THE PROBOLINGGO – BANYUWANGI TOLL ROAD PROJECT PEKET 2: STA 9+000 – 20+200

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Abstract

The government is building toll roads in various regions in Indonesia to realize economic acceleration and minimize economic inequality in society. However, based on facts on the ground, there are still many delays in toll road construction projects which are detrimental so it is necessary to take steps to accelerate the work. The aim of this research is to analyze the time and costs of accelerating the Probolinggo – Banyuwangi Toll Road construction project STA 9+000 – 20+200 using the Crashing Method. This type of research is quantitative research with the research subject being PT. Hutama Karya Indonesia (HKI) as the project implementing contractor. The research uses secondary data, namely the Draft Expenditure Budget (RAB), Schedule, weekly reports, and project costs for the completion of Toll Road construction work. The data collection method was carried out using observation and documentation methods. The research data analysis technique uses the Crashing. The results of research state: 1) On work on the Probolinggo – Banyuwangi Toll Road project Job STA 9+000 – 20 +200 job time can be accelerated to 311 days, which originally lasted 394 days. 2) Application of the Crashing Method to the Probolinggo Toll Road project– Banyuwangi STA Jobs 9+000 – 20+200 with critical path on public works, workplace cleaning, earthworks, drainage, sub grade, aggregate base layer, pavement, work others, traffic light lighting and electrical works, plazas Tolls, and work on toll facilities and toll gate offices can saving 115 days of work time with additions cost Rp. 72,941,450,191.64.

Keywords: *Crashing, Construction Work, Toll Road*

1. INTRODUCTION

Roads are important infrastructure to facilitate the distribution of goods and distribution factors between regions and increase population mobility. Road infrastructure has a very important role in the running of the economic system. The better the condition of the infrastructure, the better the influence on the economic situation (Sumaryoto 2010). In general, the condition of road infrastructure in Indonesia is still very slow compared to other neighboring countries (ISEI 2005). This can be proven by the lack of toll roads in Indonesia compared to other countries such as China. Based on data from the PUPR Ministry, there are 68 toll road sections operating in Indonesia in 2022. The total length of the operational toll roads reaches 2,545 kilometers (Rizaty, n.d.). Even though there is an increase in the number of toll roads and the length of toll roads every year, they are still behind China, which has a total toll length of more than 100,000 km.

Toll roads are important transportation infrastructure in the economic development of a country because they have several advantages that are much needed in the mobility of people and goods (Julitim 2021). Toll roads have a strategic role in supporting infrastructure development and economic growth, because they can increase connectivity between cities and regions, facilitate the movement of goods and services, and increase regional competitiveness in the era of globalization (Kementerian Keuangan Republik Indonesia, 2023). The advantage that toll roads have compared to other roads is that they are able to increase the efficiency of transportation time and costs, speed up the distribution of goods between regions, increase accessibility and increase energy efficiency. According to Article 43 of Law No. 38 of 2004, toll roads are implemented to: 1) Facilitate traffic in developing areas, 2) Increase the usability and efficiency of goods and services distribution services to support increased economic growth, 3) Lighten the burden on government funds through road user participation and 4) Increasing the distribution of development results and justice. Construction projects are activities aimed at building facilities and infrastructure within a planned time period. A project is an activity carried out with limited time and resources to achieve a specified final result (Alamsyah 2019). With limited time and the demands of construction work which must produce buildings on cost, time and quality, construction work must be carried out as well as possible. However, based on the actual facts, there are still many delays in project implementation.

Delays in completing construction projects are often unavoidable. As a result, schedule delays may become a major problem for contractors as well as owners, resulting in costly disputes, contentious issues and detrimental relationships between all project participants. Completion of an infrastructure project on time is a top priority, time and human resource factors influence operational costs, especially labor costs. The problem that often occurs is project delays caused by inaccurate project planning, resulting in project failure which impacts all workers involved in the project.

The Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road Project is one of the Trans Java projects that connects cities in East Java to Banyuwangi as the easternmost city on the island of Java. The Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road construction project was carried out in collaboration by three contractors, namely PT. Acsent Indonusa TBK (Acset), PT. Nindya Karya (NK) and PT. Hutama Karya Infrastruktur (HKI) as project leader. The total value of work on this project is Rp. 1,669,796,439,000 with a work period of 547 calendar days and a maintenance period of 1095 calendar days. The main road that will be worked on is 11.2 km long, stretching from Kraksaan to Paiton. This project started on March 8 2023. In the implementation of the construction of the Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road, it can be seen that there were several obstacles during the work phase. This can be seen from the discrepancy between the work schedule and progress that has been prepared with the actual schedule and progress in the field. From the S Curve value, it can be seen that there was a deviation in Weeks 5 to 30 of October of -7.928% which can be interpreted as a delay in work progress. So it can be concluded that the implementation of the construction of the Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road is not running optimally because it is not in accordance with the work schedule, so it needs to be accelerated.

To resolve the problem of project delays, accelerated project scheduling can be carried out by taking into account the Triple Constraint factors including Cost, Quality and Time Factors. One scheduling method can be the Crashing. Crashing method is a way of doing estimates of the cost variables in determining maximum reduction in duration at the most economical cost activities that are still possible to reduce. The Crashing process is focused on activities that is on the critical path. In carrying out a construction project activity exists various jobs, especially in projects building these types of activities can reach tens, hundreds or even thousands of activity items (Fernando et al., 2020)

Based on the background above, it can be concluded that road infrastructure is a vital thing needed by society as a means of mobility and driving the economy. However, the implementation of development is still hampered by delays which cause the toll road to not be completed according to schedule and result in the acceleration of the Indonesian economy not being realized. From the problems discussed above, the objectives of this research are: (1) Calculating the optimal time for the Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road construction project according to the Crashing. (2) Calculate the total costs that must be incurred in accelerating the Probolinggo – Banyuwangi STA 9+000 – 20+200 Toll Road construction project using the Crashing

2. LITERATURE REVIEW

2.1. Project Definition

Schwalbe (2006), translated by Dimyati (2014), explains that a project is a temporary effort to create a unique product or service. In general, projects involve several people whose activities are related to each other and the main project sponsor is generally interested in the effective use of resources to complete the project efficiently and on time.

2.2. Project Limitation

According to Schwalbe (2006) every project has different constraints on scope, time and cost which are usually referred to as triple constraints.

2.3. Toll Roads

Toll roads are transportation infrastructure that is important in the economic development of a country because it has several advantages that are much needed in the mobility of people and goods (Juliatim, 2021).

2.4. Crashing

The Crashing method is a way of estimating variable costs to determine the maximum duration reduction with the most economical costs for activities that are still possible to reduce (Fernando, T. 2020).

2.5. Acitivity Duration

Worker productivity is used as a source of uncertainty to construct probabilistic schedules (Brando 2017). In determining the duration of work, it is necessary to know the coefficient calculation technique and the work to be calculated. Labor/equipment requirements are calculated based on the AHSP coefficient multiplied by the volume of work.

3. RESEARCH METHODS

3.1. Research Design or Research Flow Chart

The research design was carried out by identifying the time and costs for implementing the Probolinggo – Banyuwangi Toll Road construction project Package 2: STA 9+000 – 20+200.

3.2. Research Subject

The research subject in this research is the contractor implementing the project for completing the construction of the Probolinggo – Banyuwangi Toll Road STA 9+000 – 20+200, namely HKI-ACSET-NK. KSO. The research object in this research is the completion of the Probolinggo – Banyuwangi Toll Road construction work, Package 2 STA 9+000 – 20+200.

3.3. Research Location and Time

The research was carried out on the completion of the Probolinggo – Banyuwangi Toll Road construction work project Package 2 STA 9+000 – 20+200.

3.4. Research Instrument

This research uses secondary data from the Draft Expenditure Budget (RAB), Schedule, weekly reports, and project costs for the completion of the Probolinggo – Banyuwangi Toll Road construction work Package: 2 STA 9+000 – 20+200. This data was obtained from the results of field observations of contractors implementing the project to complete the Probolinggo – Banyuwangi Toll Road construction work. Package: 2 STA 9+000 – 20+200. The data source used in the research comes from secondary data. The research uses secondary data, namely RAB and Time Schedule.

3.5. Data Collection Procedures

The steps taken are as follows: (a) Formulate the purpose of data collection. (b) Determine data parameters (c) Determine data collection methods. The methods used in collecting data include: Observation and Documentation Methods.

3.6. Data Analysis

In this research, the Crashing method will be used, especially in project scheduling. The project that will be scheduled is the Probolinggo – Banyuwangi Toll Road construction project Package 2: STA 9+000 – 20+200. In the Crashing method, there are two estimates of time and costs for each activity in the network. These two estimates are a normal estimate of completion time and costs (Normal Estimate) and an accelerated estimate of time and costs (Crash Estimate).

4. RESULTS AND DISCUSSION

4.1. Project Contract Data

The construction project for the Probolinggo-Banyuwangi Toll Road Development Project is planned for 2 STA 9+000 – 20+200 under the orders of the Ministry of Public Works & Public Housing of the Republic of Indonesia which is planned to start from the beginning of 2023 with a period of 2 years which is targeted to be completed in 2024.

Project Name	: Construction of the Probolinggo - Banyuwangi Toll Road
Package 2	: STA. 09+000 – STA.20+200
Location	: Probolinggo Regency, East Java Province
Assignee	: PT. Jasamarga Probolinggo Banyuwangi
Service Provider	: PT. Hutama Karya -ACSET-Nindya Karya KSO
Implementation Time	: 394 Calendar Days
Planning Consultant	: PT. BUANA ARCHICON
Supervision consultant	: PT. MULTHI PHE BETHA

4.2. Toll Road Construction Project Cost Plan

The data source used in the research comes from secondary data. Secondary data is data obtained from other parties that is relevant to the problems raised in this research. This research only uses secondary data, namely RAB and Time Schedule.

Table 1. Project Cost Budget Plan

No	Job description	The amount of costs
1	General	57.317.042.770,00
2	Workplace Cleaning	6.422.858.955,53
3	Demolition	1.008.695.000,00
4	Earthworks	567.076.984.887,90
5	Structure Excavation	2.333.989.166,64
6	Drainage	61.549.743.580,31
7	Sub Grade	2.860.306.816,00
8	Aggregate Foundation Layer (Subbase)	36.050.659.731,96
9	Pavement	219.531.830.647,79
10	Concrete Structures	369.198.116.699,13
11	Miscellaneous Work	140.893.004.460,48
12	Traffic Light Lighting And Electrical Work	10.957.130.029,60
13	Toll Plaza	3.323.007.450,00
14	Redirection And Protection Of Existing Utilities	15.756.000.000,00
15	Toll Facility and Toll Gate Office Work	10.041.746.130,00
	Total	**1.504.321.116.325,34**

Source: Research Secondary Data (2023)

This calculation is an analysis of the overall time of the work item or the fastest time (early start) and the slowest time (late start) as well as the fastest time when the work must be finished (early finish) and the longest time the work must be finished (late finish). Apart from that, calculations will also be carried out to find the critical path for each activity. In determining the project schedule, you must first know the duration of each work item and create a logical dependency relationship for each work item using Microsoft Project 2016 software.

After filling in the required data in the Microsoft Project 2016 application, you can see the Probolinggo - Banyuwangi Package 2 STA Toll Road Construction project. 09+000 – STA.20+200 for 394 working days, the project started on March 7 2023 and finished on August 5 2023. The following are the results of the scheduling analysis of the Microsoft Project 2016 application in the form of a network diagram:

Name	Start	Finish	Duration
Penyelesaian Seluruh Pekerjaan	Mon 03/04/23	Mon 05/08/24	373 days
Penyelesaian Seluruh Pekerjaan	Mon 08/05/23	Mon 05/08/24	357 days
Penyelesaian Seluruh Pekerjaan	Sat 15/04/23	Mon 05/08/24	363 days
Perkerasan Beton Semen (Fs 4,5 Mpa)	Wed 29/05/24	Sat 27/07/24	50 days
Perkerasan Beton Semen Double Wire Mesh	Wed 29/05/24	Sat 27/07/24	50 days
Perkerasan Beton Semen Single Wire Mesh	Wed 29/05/24	Sat 27/07/24	50 days
Selokan , Tipe DS-8	Mon 29/07/24	Mon 05/08/24	7 days
Trash Rack @ 1,5x1,5	Mon 29/07/24	Mon 05/08/24	7 days
Trash Rack @ 2x2	Mon 29/07/24	Mon 05/08/24	7 days
Bak Peredam Saluran , Tipe BK-1	Mon 29/07/24	Mon 05/08/24	7 days
Bak Peredam Saluran , Tipe BK-2	Mon 29/07/24	Mon 05/08/24	7 days
Perkerasan Beton Semen (Fs 4,5 Mpa)	Tue 04/06/24	Wed 31/07/24	49 days
Perkerasan Beton Semen Single Wire Mesh	Tue 04/06/24	Wed 31/07/24	49 days
Trash Rack @ 1,5x1,5	Thu 01/08/24	Mon 05/08/24	4 days
Catchbasin, Tipe DC-1	Thu 01/08/24	Mon 05/08/24	4 days
Bak Peredam Saluran , Tipe BK-1	Thu 01/08/24	Mon 05/08/24	4 days
Inlet Drain, Tipe DI-1	Thu 01/08/24	Mon 05/08/24	4 days
Bahan Porous untuk Penimbunan atau Bahan Penyaring (Filter)	Thu 01/08/24	Mon 05/08/24	4 days
Pipa Berlubang Banyak (Perforated Pipe) untuk Drainase Bawah Permukaan Dia.6 inch	Thu 01/08/24	Mon 05/08/24	4 days
Solid Sodding	Fri 19/07/24	Mon 05/08/24	15 days
Patok Pengarah (Guide Post) Tipe A	Fri 19/07/24	Mon 05/08/24	15 days
Patok Pengarah (Guide Post) Tipe B	Fri 19/07/24	Mon 05/08/24	15 days
Patok Kilometer	Fri 19/07/24	Mon 05/08/24	15 days
Pagar Rumija Tipe 1 (Panel Beton)	Fri 19/07/24	Mon 05/08/24	15 days
Pagar Rumija Tipe 2 (Kawat Berduri)	Fri 19/07/24	Mon 05/08/24	15 days
Concrete Barrier, Tipe B (1 Muka)	Fri 19/07/24	Mon 05/08/24	15 days
Guardrail Kendaraan Tipe A	Fri 19/07/24	Mon 05/08/24	15 days
Bagian Ujung Guardrail	Fri 19/07/24	Mon 05/08/24	15 days
Marka Jalan, Tipe A-1 (Penerapan Umum, Warna Putih)	Fri 19/07/24	Mon 05/08/24	15 days
Marka Jalan, Tipe A-2 (Penerapan Umum, Warna Kuning)	Fri 19/07/24	Mon 05/08/24	15 days
Marka Jalan, Tipe B-1 (Penerapan Umum, Warna Putih)	Fri 19/07/24	Mon 05/08/24	15 days
Lampu Penerangan Bawah Jembatan/Tunel (1 x 80 Watt) Jenis LED	Fri 19/07/24	Mon 05/08/24	15 days

Source: Researcher Processed Data (2023)

Figure 1. Network Diagram of the Probolinggo - Banyuwangi Toll Road Construction Project

Based on the results of the 2016 Microsoft Project application analysis, there are several types of work and volumes that are included in the critical path as follows:

Table 2. Project Cost Recapitulation

No.	Type of work	Unit	Volume	Duration
1	Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700	m^3	17,009.46	50
2	Double Wire Mesh Cement Concrete Pavement STA 15+200 - STA 16+176	m^3	402.60	50
3	Sewer, Type DS-8 STA 15+200 - STA 17+700	m	3,560.88	7
4	Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500	m^3	9,126.00	49
5	Inlet Drain, Type DI-1 STA 17+700 - STA 19+000	Bh	46.00	4
6	Porous Material for Hoarding or Filter Material STA 17+700 - STA 19+000	m^3	136.45	4
7	Perforated Pipe for Subsurface Drainage Dia.6 inch STA 17+700 - STA 19+000	m	200.00	4
8	Solid Sodding STA 17+700 - STA 19+000	m^2	41,927.06	15

No.	Type of work	Unit	Volume	Duration
9	Guide Post Type A STA 17+700 - STA 19+000	bh	188.00	15
10	Guide Post Type B STA 17+700 - STA 19+000	bh	188.00	15
11	Rumija Fence Type 1 (Concrete Panel) STA 17+700 - STA 19+000	m	970.00	15
12	Rumija Fence Type 2 (Concrete Panel) STA 17+700 - STA 19+000	m	817.00	15
13	Concrete Barrier, Tipe B (1 Muka) STA 17+700 - STA 19+000	m	4,738.40	15
14	Guardrail Vehicle Type A STA 17+700 - STA 19+000	m	2,713.00	15
15	Road Markings, Type A-1 (General Application, White) STA 17+700 - STA 19+000	m^2	630.00	15
16	Road Markings, Type A-2 (General Application, White) STA 17+700 - STA 19+000	m^2	630.00	15
17	Road Markings, Type B-1 (General Application, White) STA 17+700 - STA 19+000	m^2	242.31	

Source: Researcher Processed Data (2023)

From the list of jobs on the critical path, jobs that require labor and heavy equipment can be seen as types of work that have a longer duration and quite large volume. From the data provided, the following jobs most likely require labor and heavy equipment:

Table 3. List of Critical Activities with Western Labor & Tool Resources

No.	Type of work	Unit	Volume	Duration
1	Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700	m^3	17,009.46	50
2	Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500	m^3	9,126.00	49
3	Solid Sodding STA 17+700 - STA 19+000	m^2	41,927.06	15
4	Concrete Barrier, Type B (1 Face) STA 17+700 - STA 19+000	m	4,738.40	15
5	Guardrail Vehicle Type A STA 17+700 - STA 19+000	m	2,713.00	15

Source: Researcher Processed Data (2023)

These jobs were of significant duration (between 15-50 days) and relatively large volumes, indicating that they likely required labor and heavy equipment to complete the tasks.

4.3. Time Cost Trade Off Test

If the implementation time is accelerated, the direct costs of the project will increase and the indirect costs of the project will decrease. The application of the duration cost trade off method in this research was carried out in two ways to speed up project completion time, including:

1) Additional overtime hours for 1 – 3 hours

In planning additional overtime working hours, 7 normal working hours and 1 rest hour (08.00-16.00) are used, while overtime work is carried out after normal working hours (16.00-19.00). According to the decree of the Minister of Manpower Number KEP.102/MEN/VI/2004 article 3, article 7 and article 11 the standard wages for overtime are:

a. Overtime work can only be done at a maximum of 3 (hours) in 1 (one) day and 14 (fourteen) hours in 1 (one) week.
b. Provide food and drink of at least 1,400 calories if overtime work is done for 3 hours or more.
c. The first overtime work must be paid at 1.5 times the hourly wage.
d. For each subsequent hour of overtime work, wages must be 2 times the hourly wage.

Table 4. List of Critical Activities with Western Labor & Tool Resources

No	Type of Worker	Labor Price/Hour	Labor Price/Day
1	Worker	15.000	120.000
2	Craftsman	18.000	144.000
3	Foreman	21.000	168.000
4	Operator	35.000	280.000
5	Operator Assistant	20.000	160.000
6	Driver	25.000	200.000
7	Driver Assistant	15.000	120.000

Source: AHS data from PT project. Hutama Karya -ACSET-Nindya Karya KSO(2023)

2) Overtime Cost Analysis for Workers and Heavy Equipment

For more details, normal and overtime costs for labor and heavy equipment on the critical path can be seen in the following table:

Table 5. Normal Costs, Heavy Equipment Overtime Costs, and Labor

Workers / Heavy Equipment	Cost Normal Hourly (Rp)	*Overtime Cost*		
		Overtime 1 O'clock 1.00	Overtime 2 O'clock 2.00	Overtime 3 O'clock 3.00
Worker	15,000	22,500	30,000	37,500

Workers / Heavy Equipment	Cost Normal Hourly (Rp)	*Overtime Cost*		
		Overtime 1 O'clock 1.00	Overtime 2 O'clock 2.00	Overtime 3 O'clock 3.00
Craftsman	18,000	27,000	36,000	45,000
Foreman	21,000	31,500	42,000	52,500
Operator	35,000	52,500	70,000	87,500
Operator assistant	20,000	30,000	40,000	50,000
Foreman	30,000	45,000	60,000	75,000
Excavator Back Hoe,	745,800	1,118,700	1,491,600	1,864,500
Dump truck,	1,137,200	1,705,800	2,274,400	2,843,000
Vibro Compactors	1,036,800	1,555,200	2,073,600	2,592,000
Roller	608,700	913,050	1,217,400	1,521,750
Water Tanker Truck	634,900	952,350	1,269,800	1,587,250
Concrete Pump Truck	926,700	1,390,050	1,853,400	2,316,750
Concrete Mixer	1,082,700	1,624,050	2,165,400	2,706,750
Truck Crane	3,654,300	5,481,450	7,308,600	9,135,750
Concrete Mixer	547,400	821,100	1,094,800	1,368,500
Welding Set	24,700	37,050	49,400	61,750

Source: Researcher Processed Data (2023)

Based on the table of normal costs and overtime costs for workers and heavy equipment presented, overtime cost analysis is very important in managing construction projects. This table provides a detailed view of the costs involved when workers or heavy equipment have to work longer than normal hours.

In situations where projects face time constraints or require accelerated completion, understanding overtime costs for workers and heavy equipment becomes crucial. The table provides a clear picture of the additional costs that will be incurred for each type of worker or heavy equipment when the work duration exceeds normal working hours. Using information from this table, project managers can make more accurate cost estimates when planning or accelerating completion of a phase of a project. This allows them to make more informed decisions regarding resource use, when overtime can be applied, and how to manage the budget more efficiently.

4.4. Acceleration Duration Analysis

Overtime work productivity for 1 hour per day is calculated at 90%, 2 hours per day is calculated at 80%, and 3 hours per day is calculated at 70% of normal productivity. The decrease in productivity for overtime work is caused by fatigue of operators and operator assistants, limited visibility at night, and cold weather conditions.

As a result of observations and interviews with the project manager, the delay in completing this project was caused by several factors, namely unpredictable weather conditions, damage to equipment which required equipment to be repaired first, field conditions such as muddy and waterlogged, and the surrounding community who held demonstrations rejecting the activity (Suherman, & Hariono 2016).

Table 6. Costs for the normal duration of critical work that requires Labor and Heavy Equipment

No.	Type of activity	Duration	Job Volume	Price Unit	Price Total
1	Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700	50	7,009.46	1,798,700.00	2,607,915,702.00
4	Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500	49	9,126.00	1,798,700.00	16,414,936,200.00
8	Solid Sodding STA 17+700 - STA 19+000	15	41,927.06	18,580.00	779,004,774.80
13	Concrete Barrier, Type B (1 Face) STA 17+700 - STA 19+000	15	4,738.40	1,332,960.00	6,316,097,664.00
14	Guardrail Vehicle Type A STA 17+700 - STA 19+000	15	2,713.00	738,080.00	2,002,411,040.00

Source: Researcher Processed Data (2023)

For the duration of acceleration of all work on the critical path, which requires additional labor and heavy equipment, see the table below:

Table 7. Recapitulation of Normal Duration, Crash Duration, Total Crash

No.	Type of work	Normal Duration (Day)	Duration Crach (Day)	Total Crach (Day)
1	Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700	50	38	12
4	Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500	49	37	12
8	Solid Sodding STA 17+700 - STA 19+000	15	12	3
13	Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500	15	12	3
14	Guardrail Vehicle Type A STA 17+700 - STA 19+000	15	12	3

Source: Researcher Processed Data (2023)

From this table, it can be seen that there is a difference between the normal duration and the crash duration for each type of work. Crash duration indicates how much time can be shaved off the normal duration of the project. For example, for the type of work 'Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700', the normal duration is 50 days. However, through accelerated planning, the duration can be cut to 38 days with a total time reduction of 12 days. Something similar happens to the other types of work in the table.

4.5. Acceleration Cost Analysis

In calculating the total costs of accelerating each job, it is assumed that equipment rental prices and material prices do not change.

Table 7. Calculation results of daily cost slope and acceleration cost slope

No.	Type of wc=ork	Normal Duration	Duration	Total	*Cost Slope*	*Cost Slope*
		(Day)	*Crach*	*Crach*	Every Day	Acceleration
			(Day)	(Day)	(Rp)	(Rp)
1	Cement Concrete Pavement (Fs 4,5 Mpa) STA 15+200 - STA 17+700	50	38	12	Rp 28.703.274,01	Rp 344.439.288,12
4	Cement Concrete Pavement (Fs 4,5 Mpa) STA 17+700 - STA 18+500	49	37	12	Rp. 37.563.399,69	Rp 450.760.796,29
8	Solid Sodding STA 17+700 - STA 19+000	15	12	3	Rp 22.772.494,08	Rp 68.317.482,23
13	Concrete Barrier, Type B (1 Face) STA 17+700 - STA 19+000	15	12	3	Rp 184.637.246,53	Rp 55.391.173.958,00
14	Vehicle Guardrail Type A STA 17+700 - STA 19+000	15	12	3	Rp 1.390.563.222,00	Rp 16.686.758.667,00
TOTAL					Rp1.664.239.636	Rp72.941.450.191,64

Source: Researcher Processed Data (2023)

In the Acceleration Cost Analysis sub-chapter, the findings from the table presented are regarding the acceleration costs (cost slope) of each type of work. This indicates the additional costs that need to be incurred to accelerate the project duration from normal duration to crash duration.

1. Cement Concrete Pavement (Fs 4.5 Mpa) STA 15+200 - STA 17+700: Acceleration of 12 days results in additional costs of Rp. 344,439,288.12.
2. Cement Concrete Pavement (Fs 4.5 Mpa) STA 17+700 - STA 18+500: Acceleration duration 12 days with additional cost Rp. 450,760,796.29.
3. Solid Sodding STA 17+700 - STA 19+000: 3 day acceleration adds costs of Rp. 68,317,482.23.
4. Concrete Barrier, Type B (1 Face) STA 17+700 - STA 19+000: 3 day acceleration with additional cost Rp. 55,391,173,958.00.
5. Guardrail Vehicle Type A STA 17+700 - STA 19+000: 3 day acceleration adds costs of Rp. 16,686,758,667.00.

So the total acceleration costs for all types of work are IDR 72,941,450,191.64. From the analysis results, it appears that accelerating this project requires significant additional costs. For example, accelerating the duration of Concrete Barrier work, Type B (1 Face) STA 17+700 - STA 19+000 by 3 days causes additional costs of up to Rp. 55,391,173,958.00. Meanwhile, Guardrail Vehicle Type A STA 17+700 - STA 19+000 with the same acceleration of 3 days adds a cost of Rp. 16,686,758,667.00. This shows that the benefits of project acceleration must be carefully considered in relation to the additional costs that must be incurred. Project managers must have a deep understanding of the balance between the benefits of accelerated project completion and the additional costs involved. This analysis allows project managers to make informed decisions about the most effective and efficient scheduling strategies for the Probolinggo - Banyuwangi Toll Road project.

5. CONCLUSION

In accordance with the research objectives and results of the discussion, it can be concluded that: 1) In the work on the Probolinggo – Banyuwangi Toll Road project, STA 9+000 – 20 +200, the work time can be accelerated to 311 days, which previously lasted 394 days. 2) Application of the Crashing Method on the Probolinggo – Banyuwangi Toll Road project STA Work 9+000 – 20+200 with critical paths in public works, workplace cleaning, earthworks, drainage, sub grade, aggregate foundation layer, pavement, other work- other things, traffic light lighting and electrical work, toll plazas, and work on toll facilities and toll gate offices can save 115 days of work time with an additional cost of Rp. 72,941,450,191.64.

So that further research can provide better and more detailed results, there are several suggestions that can be followed up, namely: 1) The results of cost optimization and shorter time will require greater implementation costs, but will not make the contractor lose costs. 2) Research using Crashing analysis can continue to be developed, it is hoped that future researchers can use other acceleration alternatives that are more effective and efficient.

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