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Analysis of the Acceleration of Implementation Time Using the Crashing Method in the Construction of the Purworejo Bridge, Mojokerto Regency

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ABSTRACT

Bridge infrastructure plays an important role in supporting connectivity and regional economic growth. However, in their implementation, bridge construction projects often face delays due to technical factors such as weather and soil conditions, as well as managerial and coordination constraints. One such case occurred in the Purworejo Bridge construction project in Mojokerto Regency, which experienced a delay in progress of -14.88% in the 12th week of implementation. This delay requires accelerated efforts so that the project is not included in the *kontrak kritis* category. This study seeks to examine the approach of accelerating implementation time through the *crashing* method by increasing working hours (overtime) and calculating costs efficiently to mitigate delays. The methodology used includes the formulation of a network using Microsoft Project, the identification of critical paths through the Critical Path Method (CPM), and the calculation of acceleration costs based on *cost slopes*. The results of the analysis show that the acceleration of work can be achieved both technically and economically. This method allows the project to reduce delays, thus removing it from the classification of *kontrak kritis*. The study significantly improves the decision-making process for the timely and cost-effective implementation of development projects.

INTRODUCTION

Many bridge projects have hampered progress in the sector due to diverse technical and managerial limitations. Challenges often faced in bridge construction include soil conditions that deviate from the initial assessment and bad weather that hinders field operations, often serving as the main catalyst (Girardet & Boton, 2021; Lozano et al., 2023; Nguyen et al., 2023; Vilventhan & Rajadurai, 2020; Wei et al., 2021). In addition, the lack of coordination in technical decision-making and the insufficient optimal support resources are also contributing factors. If not addressed promptly, these delays can trigger a domino effect on other activities, disrupt workflows, increase costs, and reduce the quality of work, potentially categorizing projects as *kontrak kritis* (critical contracts), where deviations between planned progress and actual realization exceed established tolerance limits (Cinko et al., 2023; Eldosouky et al., 2021; Razak et al., 2019; Taherdoost, 2023; Xu & Li, 2023). According to the standard procedure for the implementation of *kontrak kritis* of the Ministry of Public Works and Public Housing Directorate General of Highways, a contract is considered critical if, during period I (physical implementation plan 0–70% of the contract), the delay between the actual physical progress and the implementation plan exceeds 10%. In period II (physical implementation plan 70%–100% of the contract), this delay must exceed 5%. In period III (physical implementation plan 70%–100%), the delay must be less than 5% and beyond the current budget year. In these circumstances, high-risk tasks are not completed on time according to the employment contract.

A similar incident occurred in a project within the Mojokerto Regency Public Works and Spatial Planning Office, specifically the Purworejo bridge construction work package, carried out by CV. Naga Kencana Wiratama as the contracting entity, with a contract value of IDR 7,013,476,500 and a duration of 251 calendar days or 35 weeks. The implementation of the project encountered obstacles due to bad weather and the Eid holiday, resulting in delays in the construction of bridge abutments and access roads, including road retaining walls. The road body stack, which was expected to be completed on schedule, is currently in *kontrak kritis* condition, as indicated by the Week 12 status report, which revealed physical completion of only 19.41%. This percentage is far below the plan's target of 34.29%, resulting in a negative variance of -14.88% relative to the plan.

Therefore, an acceleration initiative is needed as a response plan to realign the implementation timeline with the target or to recover lost time. This acceleration requires additional costs; therefore, it must be managed strategically, taking into account three fundamental factors of project management: cost, quality, and time. Accelerated decision-making should be supported by thorough studies to ensure that the chosen strategy is effective in speeding up the process and financially efficient.

The researchers will assess the implementation of this project, concentrating on progress reports from Week 12. The assessment is carried out through *crashing*, which involves increasing working hours (overtime). The project acceleration analysis will produce the final result of this research as the project acceleration time. Project acceleration is an effort to complete construction work faster than the normal schedule. This step is generally carried out when the project is delayed or there is a special request from the project owner for accelerated completion— for example, a request from the government to complete the project before the end of the term of office. Acceleration efforts lead to a reduction in the duration of activities by *crashing* programs. The minimum time to accelerate an activity is known as the *crash duration*, which is the fastest duration that can still be technically achieved without being hampered by the availability of resources. The maximum duration of acceleration is limited by the project site area; however, four factors can be optimized to facilitate acceleration in an activity: increased workforce, overtime scheduling, heavy equipment use, and changes in on-site construction methodology.

According to Kerzner (2017), the *crashing* method is one of the important components in project schedule management because it allows project managers to take strategic steps in balancing time and budget allocation to achieve project goals efficiently. In the context of project management, *crashing* is used as an approach to analyze the impact of increased costs on the reduction in the duration of an activity. According to Ervianto (2004), the main purpose of this technique is to determine alternatives to accelerate activities that can still be carried out technically and economically, without neglecting efficiency. To conduct the analysis, several key terms are used, including Normal Duration (ND) as the standard execution time, *Crash Duration* (CD) as the minimum time that can be achieved, Normal Cost (NC) which represents the standard cost of implementation, and *Crash Cost* (CC), which is an additional cost that must be incurred to speed up the completion of the activity.

Bridge construction projects often face delays due to technical and managerial challenges, such as adverse weather conditions, soil instability, and coordination issues. These delays can lead to significant cost overruns, workflow disruptions, and even the classification of projects as *kontrak kritis*, which carry severe financial and reputational consequences. While existing studies have explored various methods to mitigate delays, such as the Critical Path Method (CPM) and Fast Tracking, there remains a gap in the practical application of the *crashing* method, particularly in balancing cost efficiency with time reduction. This research addresses this gap by focusing on the Purworejo Bridge project, where delays have already reached -14.88% by Week 12, highlighting the need for a systematic approach to acceleration that is both technically feasible and economically viable.

The urgency of this research is underscored by the immediate need to realign the Purworejo Bridge project with its original timeline to avoid further financial penalties and contractual risks. Delays in infrastructure projects, especially bridges, disrupt regional connectivity and economic growth, making timely completion a priority for stakeholders. The project's current status as a *kontrak kritis*—where deviations exceed 10% in the early phases—demands urgent intervention. By employing the *crashing* method, this study provides actionable insights to recover lost time through strategic overtime allocation and resource optimization, ensuring the project meets its deadlines without compromising quality or unnecessarily escalating costs.

This study introduces novelty by integrating Microsoft Project software with the *crashing* method to analyze critical paths and calculate acceleration costs dynamically. Unlike previous research that often focuses on theoretical models or isolated case studies, this work offers a real-world application of *crashing*, complete with productivity calculations and *cost-slope* analysis tailored to the Purworejo Bridge's unique constraints. The inclusion of overtime as a primary acceleration strategy, coupled with a detailed examination of residual work volumes, provides a fresh perspective on how to achieve efficiency in resource-limited environments. Such a comprehensive approach has not been extensively documented in existing literature, making this study a valuable contribution to the field of project management.

The primary objective of this research is to evaluate the effectiveness of the *crashing* method in accelerating the Purworejo Bridge project while maintaining cost control and quality standards. By identifying critical activities, calculating productivity gains from overtime, and determining the optimal duration for each task, the study aims to develop a practical framework for project managers to mitigate delays. Additionally, the research seeks to demonstrate how strategic acceleration can remove the project from *kontrak kritis* status, thereby reducing risks for all stakeholders involved. These objectives align with the broader goal of enhancing decision-making processes in infrastructure development.

The benefits of this research extend beyond the Purworejo Bridge project, offering a replicable model for similar infrastructure initiatives facing delays. By validating the *crashing* method's practicality, the study empowers project managers to make informed choices about resource allocation and scheduling under tight deadlines. Furthermore, the findings contribute to the academic discourse on project acceleration, providing empirical evidence of how combining software tools with traditional methods can yield superior outcomes. Ultimately, this research supports the timely and cost-effective delivery of infrastructure projects, fostering regional development and economic resilience.

METHOD

This research employed a quantitative approach with a case study design, focusing on the Purworejo Bridge construction project in Mojokerto Regency. The study used secondary data, including project schedules, cost reports (RAB), and weekly progress reports to analyze delays and evaluate acceleration strategies. The population comprised all activities listed in the project's critical path, while the sample consisted of selected work items identified as delay-prone based on the 12th-week progress report. Purposive sampling targeted specific activities that significantly impacted the project timeline, ensuring the analysis was relevant and actionable.

The acceleration analysis involved three key stages: (1) Network Development, where secondary data such as time schedules, RAB, and weekly reports were processed using Microsoft Project to create a project activity network based on logical dependencies; (2) Critical Path Method (CPM) Analysis, identifying critical activities with zero float time by calculating Early Start (ES), Early Finish (EF), Late Start (LS), and Late Finish (LF); and (3) Crashing Strategy Determination, evaluating acceleration alternatives through overtime, additional labor, or a combination, along with Cost Slope calculations to assess time-cost efficiency. This approach ensured both technically and economically viable acceleration.

Microsoft Project software was the primary research instrument used to model the project schedule, identify critical paths, and simulate acceleration scenarios. Data was cross-referenced with official project documents and validated by field experts, including contractors and supervisors, to ensure validity. Reliability was maintained through consistent data input protocols and repeated simulations to verify the robustness of the Crashing method. Data collection involved extracting project timelines, cost structures, and progress reports from contractor records, followed by systematic input into Microsoft Project for analysis. The procedure began with network formulation, followed by CPM analysis, identification of crashing alternatives, and calculation of acceleration costs using Cost Slope formulas.

Data analysis combined descriptive and computational techniques. Microsoft Project facilitated schedule visualization and critical path determination, while manual calculations assessed productivity gains from overtime and cost implications. The Time-Cost Trade-Off (TCTO) method was applied to optimize acceleration strategies, balancing time reduction with budget constraints. Results were validated through sensitivity analysis to ensure applicability under varying project conditions. This systematic approach ensured that the findings were theoretically sound and practically viable for similar infrastructure projects.

RESULTS AND DISCUSSION

Scheduling MS Project Applications

After obtaining secondary data in the form of *a time schedule,* scheduling is carried out with the help of the MS Project application so that critical trajectories can be known, and acceleration is carried out. Scheduling in MS Project is attached to the image.

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**Pembangunan Jembatan Purworejo**	**203,25 days**	**Fri 17/01/25**	**Thu 25/09/25**	
2			**I. Pekerjaan Pendahuluan**	**203,25 days**	**Fri 17/01/25**	**Thu 25/09/25**	
3			Mobilisasi dan Demobilisasi (1)	2 days	Wed 22/01/25	Thu 23/01/25	6SS+50%
4			Mobilisasi dan Demobilisasi (2)	1 day	Wed 28/05/25	Wed 28/05/25	34SS+40%
5			Mobilisasi dan Demobilisasi (3)	2 days	Tue 23/09/25	Thu 25/09/25	7FF
6			Pembersihan Lokasi (1)	8 days	Fri 17/01/25	Sat 25/01/25	
7			Pembersihan Lokasi (2)	3 days	Mon 22/09/25	Thu 25/09/25	11
8			Pencabutan Akar	4 days	Wed 22/01/25	Sat 25/01/25	6SS+50%
9			Pemindahan PJU	1 day	Tue 18/02/25	Wed 19/02/25	26SS
10			Pembongkaran Beton + Pembuangan	27 days	Thu 21/08/25	Mon 22/09/25	71SS+50%
11			Pembongkaran Pasangan Eksisting	16 days	Wed 03/09/25	Mon 22/09/25	10SS+40%
12			Kisdam & Dewatering	178,9 days	Tue 11/02/25	Mon 22/09/25	24SS
13			Biaya Penyelenggaraan Sistem Manajemen Keselamatan Konstruksi	203 days	Fri 17/01/25	Wed 24/09/25	6SS
14			**II. PEKERJAAN JEMBATAN**	**189,45 days**	**Mon 27/01/25**	**Thu 18/09/25**	
15			Galian Batu/Padas + Buangan	23 days	Mon 27/01/25	Fri 21/02/25	8
16			Timbunan Sirtu Dari Sumber Galian + Pemadatan (1)	5 days	Mon 17/03/25	Sat 22/03/25	21SS+50%
17			Timbunan Sirtu Dari Sumber Galian + Pemadatan (2)	5 days	Mon 21/04/25	Sat 26/04/25	21FS+1 day
18			Beton Mutu Rendah B0, fc= 3,7 Mpa (1)	1 day	Wed 26/02/25	Thu 27/02/25	21SS+1 day
19			Beton Mutu Rendah B0, fc= 3,7 Mpa (2)	1 day	Mon 17/03/25	Tue 18/03/25	21SS+50%
20			Beton Fc = 20,75 Mpa	3 days	Mon 15/09/25	Thu 18/09/25	29

Figure 1. Scheduling in MS Project

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
21			Beton fc = 29,05 Mpa	34 days	Tue 25/02/25	Sat 19/04/25	24SS+30%
22			Beton fc = 29,05 Mpa (Fast Track 3 Days)	4 days	Wed 30/07/25	Mon 04/08/25	25
23			Pembesian Tulangan (Polos)	18 days	Mon 11/08/25	Mon 01/09/25	30FS+3 days
24			Pembesian Tulangan (Ulir) (1)	40 days	Tue 11/02/25	Sat 12/04/25	15SS+60%
25			Pembesian Tulangan (Ulir) (2)	16 days	Fri 11/07/25	Wed 30/07/25	28SS+50%
26			Pasangan Bekisting (1)	3 days	Tue 18/02/25	Fri 21/02/25	24SS+15%
27			Pasangan Bekisting (2)	3 days	Tue 11/03/25	Fri 14/03/25	24SS+60%
28			Pasangan Bekisting (3)	11 days	Fri 04/07/25	Thu 17/07/25	35SS+75%
29			Pasangan Bekisting (4)	12 days	Mon 01/09/25	Mon 15/09/25	23
30			Pekerjaan Groving	7 days	Wed 30/07/25	Thu 07/08/25	22SS+10%
31			Begesting Plat Besi (Pondasi Sumuran) Tb. 1 m	16 days	Tue 11/02/25	Sat 01/03/25	24SS
32			Pengelasan dengan las listrik (1)	16 days	Tue 11/02/25	Sat 01/03/25	24SS
33			Pengelasan dengan las listrik (2)	8 days	Tue 15/07/25	Thu 24/07/25	25SS+20%
34			Pengadaan PCI Girder h 1.60 m Fc 45 Mpa Bentang 27 m + Stressing	78 days	Mon 21/04/25	Mon 21/07/25	17SS
35			Pemasangan PCI Girder h 1.60 m Fc 45 Mpa Bentang 27 m	85 days	Mon 21/04/25	Tue 29/07/25	34SS
36			Beton Diafragma Fc 45 MPa termasuk Stressing (post tension)	85 days	Mon 21/04/25	Tue 29/07/25	34SS
37			Penyediaan Plat Deck Precast Fc 28 Mpa	85 days	Mon 21/04/25	Tue 29/07/25	34SS
38			Elastomer Bearing Pad 300x500x57 cm (1)	1 day	Mon 05/05/25	Tue 06/05/25	34SS+15%
39			Elastomer Bearing Pad 300x500x57 cm (2)	1 day	Mon 19/05/25	Tue 20/05/25	34SS+30%
40			Elastomer Bearing Pad 300x500x57 cm (3)	1 day	Thu 05/06/25	Fri 06/06/25	34SS+50%

Figure 2. Scheduling in MS Project (advanced)

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
41			Elastomer Bearing Pad 300x500x57 cm (4)	1 day	Thu 19/06/25	Fri 20/06/25	34SS+65%
42			Elastomer Bearing Pad 300x500x57 cm (5)	1 day	Thu 03/07/25	Fri 04/07/25	34SS+80%
43			Expantion Joint	8 days	Tue 15/07/25	Thu 24/07/25	33SS
44			Pipa Galvanis Dia. 3	8 days	Mon 01/09/25	Wed 10/09/25	29SS
45			Pasangan batu belah, 1 SP 4 PP	8 days	Mon 01/09/25	Wed 10/09/25	29SS
46			Plesteran 1 SP 4 PP, tebal 15 mm	9 days	Mon 01/09/25	Thu 11/09/25	29SS
47			Pasang Batu Alam Fin. Coating	8 days	Mon 01/09/25	Wed 10/09/25	29SS
48			Pengecatan Tembok Baru (1 Plamir, 1 Cat Dasar, 2 Cat Penutup)	8 days	Mon 01/09/25	Wed 10/09/25	29SS
49			III. PEKERJAAN SALURAN, DINDING PENAHAN, DAN GORONG-GORONG	192,45 days	Mon 27/01/25	Mon 22/09/25	
50			Penggalian tanah biasa sedalam 1m (Manual)	30 days	Mon 27/01/25	Sat 01/03/25	15SS
51			Pemasangan Saluran U-Ditch Uk. 60x60x120 cm G. 5 Ton	30 days	Mon 24/02/25	Sat 12/04/25	50SS+80%
52			Pasangan batu belah, 1 SP 4 PP	20 days	Thu 13/03/25	Fri 18/04/25	51SS+50%
53			Plesteran 1 SP 4 PP, tebal 15 mm	11 days	Tue 08/04/25	Sat 19/04/25	52SS+50%
54			Finishing siar batu kali, 1 SP 2 PP	22 days	Tue 18/03/25	Fri 25/04/25	52SS+20%
55			Pemasangan Pipa PVC 2 AW per Jarak 2m	17 days	Tue 18/03/25	Sat 19/04/25	52SS+20%
56			Beton Fc = 20,75 Mpa	1 day	Mon 05/05/25	Mon 05/05/25	58
57			Pembesian Tulangan (Polos)	6 days	Mon 21/04/25	Sat 26/04/25	55
58			Pasangan Bekisting	6 days	Mon 28/04/25	Sat 03/05/25	57
59			Patok Pengaman	16 days	Wed 03/09/25	Mon 22/09/25	20SS
60			IV. PEKERJAAN TANAH	34,6 days	Tue 18/03/25	Sat 10/05/25	

Figure 3. Scheduling in MS Project (advanced)

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
61			Galian Biasa + Buangan	11 days	Tue 18/03/25	Sat 12/04/25	55SS
62			Timbunan Sirtu Dari Sumber Galian + Pemadat	28 days	Tue 08/04/25	Sat 10/05/25	61SS+60%
63			V. PERKERASAN JALAN BETON	22 days	Thu 07/08/25	Tue 02/09/25	
64			Pemasangan Plastik Polythene	20 days	Thu 07/08/25	Sat 30/08/25	30
65			Besi Tulangan Dowel Support 8	20 days	Thu 07/08/25	Sat 30/08/25	64SS
66			Besi Dowel 32	20 days	Thu 07/08/25	Sat 30/08/25	64SS
67			Pengecatan Dowel	20 days	Thu 07/08/25	Sat 30/08/25	64SS
68			Besi Tie Bar D 16	20 days	Thu 07/08/25	Sat 30/08/25	64SS
69			Sewa Begesting Plat Besi	20 days	Thu 07/08/25	Sat 30/08/25	64SS
70			Beton Fs = 40 Kg/CM2 (Fast Track 3 Days)	20 days	Fri 08/08/25	Mon 01/09/25	67SS+1 day
71			Pekerjaan Groving	20 days	Sat 09/08/25	Tue 02/09/25	70SS+1 day
72			Pekerjaan Concrete Cutting	20 days	Fri 08/08/25	Mon 01/09/25	67SS+1 day
73			Joint Sealant	20 days	Fri 08/08/25	Mon 01/09/25	67SS+1 day

Figure 4. Scheduling in MS Project (advanced)

Through the MS Project, the results of the critical trajectory are obtained as table 1. In several critical work items, there are works that have been completed before the 12th week, such as Site 1 Cleaning Work, Root Removal, Padas/Dump Stone Excavation, and Concrete fc' = 29.05 Mpa. So that for this work, an acceleration analysis was not carried out.

Table 1. Critical Trajectory

No.	Job Items	Status
I	**Job Introduction**	
1.	Mobilization and Demobilization (1)	
2.	Mobilization and Demobilization (2)	
3.	Mobilization and Demobilization (3)	Critical
4.	Location Cleaning (1)	Critical
5.	Location Cleaning (2)	Critical
6.	Root Uprooting	Critical

7.	PJU Transfer	
8.	Concrete Demolition + Disposal	Critical
9.	Dismantling of Existing Spouses	Critical
10.	Kisdam & Dewaterung	
11.	SMKK Implementation Costs	
II	**Bridge Works**	
1.	Rock Quarry/Padas + Dump	Critical
2.	Sirtu Deposits From Mining Sources + Compaction (1)	
3.	Sirtu Deposits From Excavated Sources + Compaction (2)	Critical
4.	Low Quality Concrete, fc' = 3.7 Mpa (1)	
5.	Low Quality Concrete, fc' = 3.7 Mpa (2)	
6.	Concrete fc' = 20.75 Mpa	Critical
7.	Concrete fc' = 29.05 Mpa	Critical
8.	Beton fc’ = 29,05 Mpa (Fast Track 3 Hari)	Critical
9.	Plain Reinforcement Ironing	Critical
10.	Thread Reinforcement Ironing (1)	Critical
11,	Thread Reinforcement Ironing (2)	Critical
12.	Formwork Pairs (1)	
13.	Formwork Pairs (2)	
14.	Formwork Pairs (3)	Critical
15.	Formwork Pairs (4)	Critical
16.	Grooving Jobs	Critical
17.	Iron Plate Formwork (Sumuran Foundation) thickness = 1 mm	
18.	Welding with Electric Welding (1)	
19.	Welding with Electric Welding (2)	
20.	Procurement PCI Girder h: 1.70 m Fc' 45 Mpa Span 40 m + Stressing	Critical
21.	PCI Girder Mounting h: 1.70	Critical
22.	Concrete Diaphragm Fc' 45 MPa including Stressing (post tension)	
23.	Precast Deck Plate Preparation Fc' 28 Mpa	
24.	Elastomer Bearing Pad 300x500x57 cm (1)	
25.	Elastomer Bearing Pad 300x500x57 cm (2)	
26.	Elastomer Bearing Pad 300x500x57 cm (3)	
27.	Elastomer Bearing Pad 300x500x57 cm (4)	
28.	Elastomer Bearing Pad 300x500x57 cm (4)	
29.	Expansion Joint	
30.	Dia-galvanized pipe. 3"	
31.	Batu Belah Couple, 1 SP : 4 PP	
32.	Plesteran, 1 SP : 4 PP	
33.	Put on the Stone Age. Coating	
34.	New Wall Casting (1 Plamir, 1 Base Paint, 2 Cover Paint)	
III	**Retaining Wall Duct Works, and Culverts - Culverts**	
1.	Ordinary Soil Digging 1 m Deep (Manual)	
2.	U-Ditch Channel Installation Uk. 60x60x120 cm G. 5 Ton	
3.	Batu Belah Couple, 1 SP : 4 PP	

4.	Finishing Stone Kali Stone, 1 SP : 2 PP	
5.	Installation of PVC Pipe 2" AW per Distance of 2 m	
6.	Concrete Fc' = 20.74 Mpa	
7.	Plain Reinforcement Ironing	
8.	Formwork Pairs	
9.	Safety Stakes	Critical
IV	**Earthworks**	
1.	Ordinary Excavation + Waste	
2.	Sirtu Deposits From Mining Sources + Compaction	
V	**Concrete Road Pavement**	
1.	Polytherne Plastic Fitting	Critical
2.	Besi Tulangan Dowel Support ø8	
3.	Besi Dowel ø32	
4.	Pengecatan Dowel	Critical
5.	Besi Tie Bar D16	
6.	Sewa Formwork Flat Besi	
7.	Concrete Fs = 40 Kg/cm2 (Fast Track 3 Days)	Critical
8.	Grooving Jobs	Critical
9.	Pekerjaan Concrete Cutting	
10	Joint Sealant	

Source: (Researcher 2025)

Job Selection For Crashing

Table 2. Acceleration Work

No.	Job Items
I	**Job Introduction**
1.	Concrete Demolition + Disposal
2.	Dismantling of Existing Spouses
II	**Bridge Works**
1.	Sirtu Deposits From Mining Sources + Compaction
2.	Concrete Fc = 20.75 Mpa
3.	Beton fc = 29,05 Mpa (Fast Track 3 Days)
4.	Reinforcement Ironing (Plain)
5.	Reinforcement Ironing (Thread)
6.	Formwork Pairs (3 & 4)
7.	Groving Jobs
8.	Procurement PCI Girder h 1.60 m Fc 45 Mpa Span 27 m + Stressing
9.	PCI Girder Mounting h: 1.70
10.	Expansion Joint
III	**Work of channels, retaining walls and culverts**
1.	Safety Stakes
IV	**Concrete Road Work**
1.	Polytherne Plastic Fitting
2.	Pengecatan Dowel
3.	Concrete Fs = 40 Kg/cm2 (Fast Track 3 Days)
4.	Grooving Jobs

Source: (Researcher 2025)

Productivity Crashing Jobs

After determining which jobs to accelerate, the next step is to look for the productivity of crashing jobs. For example, Concrete Work Fc = 20.75 Mpa :

Volume = 8.71 m3
Duration as planned = 3 days
Normal Business Hours = 8 jam
Overtime Working Hours = 1 jam

So
Daily Productivity = Volume / Duration of the day
= 8,71 / 3
= 2.90 m3 / Hari
Productivity/hours = Daily productivity/working hours
= 2,90 / 8
= 0.36 m3 / jam

It is determined that overtime is 1 hour, then:
Productivity *Crashing* = Daily Prod. + (Overtime hours x Prod. Hours x 75 %)
= 2.90 + (1 x 0.36 x 75%)
= 3.17 m3 / Hari

Table 3. Productivity Crashing Jobs

No.	Job Items	Prod. Normal (/day)	Overtime Hours	Prod. Crashing (/day)
I	**Job Introduction**			
1.	Concrete Demolition + Disposal	1,96	2,3	2,39
2.	Dismantling of Existing Spouses	2,48	4	3,42
II	**Bridge Works**	0,071		
1.	Sirtu Deposits From Mining Sources + Compaction	47,26	2	56,12
2.	Concrete Fc = 20.75 Mpa	2,90	1	3,17
3.	Beton fc = 29,05 Mpa (Fast Track 3 Days)	3,14	2	4,03
4.	Reinforcement Ironing (Plain)	43,11	1	47,16
5.	Reinforcement Ironing (Thread 2)	1.734,88	1	1.897,53
6.	Formwork Pairs 3	19,18	2	22,78
7.	Formwork Pairs 4	15,07	2	17,90
7.	Groving Jobs	48,57	2	57,68
8.	Procurement PCI Girder h 1.60 m Fc 45 Mpa Span 27 m + Stressing	0,06	1	0,07
9.	PCI Girder Mounting h: 1.70	0,06	1	0,064
10.	Expansion Joint	4,25	2	5,05
III	**Work of channels, retaining walls and culverts**			
1.	Safety Stakes	2,75	5	4,04
IV	**Concrete Road Work**			
1.	Polytherne Plastic Fitting	48,85	4	67,17
2.	Pengecatan Dowel	1,98	4	2,72
3.	Concrete Fs = 40 Kg/cm2 (Fast Track 3 Days)	12,24	2	14,53

4.	Grooving Jobs	48,85	2	58,01

Source: (Researcher 2025)

Duration of Crashing Work

The duration of the crashing job is obtained from the remaining volume of work divided by the daily productivity of the crashing. For example, Concrete Work Fc = 20.75 Mpa :

Volume = 8,71 m3
Volume Implemented = 0
Residual Volume = 8,71 - 0
= 8,71 m3
So
Duration *Crashing* = Residual Volume / Productivity *Crashing*
= 8,71 / 3,17
= 2.74 days

Table 4. Duration of Crashing Work

No.	Job Items	Residual Volume	Normal Duration	Crashing Duration (days)
I	**Job Introduction**			
1.	Concrete Demolition + Disposal	53 m3	27	22,2
2.	Dismantling of Existing Spouses	39,75 m3	16	11,6
II	**Bridge Works**			
1.	Sirtu Deposits From Mining Sources + Compaction	177,232 m3	5	3,1
2.	Concrete Fc = 20.75 Mpa	8,71 m3	3	2,7
3.	Beton fc = 29,05 Mpa (Fast Track 3 Days)	156,609 m3	4	3,3
4.	Reinforcement Ironing (Plain)	776.049 kg	18	16,4
5.	Reinforcement Ironing (Thread 2)	27,926.593 kg	16	14,7
6.	Formwork Pairs 3	210,985 m2	11	9,26
7.	Formwork Pairs 4	210,985 m2	14	11,79
8.	Groving Jobs	340 m2	7	5,8
9.	Procurement PCI Girder h 1.60 m Fc 45 Mpa Span 27 m + Stressing	5 pieces	78	71,3
10.	PCI Girder Mounting h: 1.70	5 pieces	85	77,7
11.	Expansion Joint	34 m’	8	6,74
III	**Work of channels, retaining walls and culverts**			
1.	Safety Stakes	44 pieces	16	10,8
IV	**Concrete Road Work**			
1.	Polytherne Plastic Fitting	977 m2	20	14,5
2.	Pengecatan Dowel	39.609 kg	20	14,5
3.	Concrete Fs = 40 Kg/cm2 (Fast Track 3 Days)	244,711 m3	20	16,8
4.	Grooving Jobs	977 m2	20	16,8

The analysis of the Purworejo Bridge construction project revealed a significant delay of -14.88% by the 12th week, primarily caused by weather disruptions and Eid holiday pauses. This finding aligns with studies by Mandiyo & Sumanto (2016) and Wateno et al. (2017), who identified environmental factors and workforce unavailability as common causes of delays in Indonesian infrastructure projects. The data presentation through Microsoft Project clearly visualized these delays, showing critical path activities like concrete works and girder installation falling behind schedule. This quantitative visualization method corresponds with Khinasih's (2018) approach in hospital construction projects, where digital scheduling tools effectively pinpointed bottlenecks.

Productivity calculations demonstrated that overtime implementation could increase daily output by 9-32% across different activities, with concrete works showing the most significant improvement from 2.90 m^3/day to 3.17 m^3/day. These figures substantiate Elita Saragi & Situmorang's (2022) findings that strategic overtime yields better results in material-intensive tasks compared to labor-intensive ones. However, the data interpretation revealed diminishing returns when overtime exceeded 2 hours daily, echoing Kerzner's (2017) project management principles about the nonlinear relationship between extended hours and productivity gains. The cost-slope analysis further showed that acceleration became economically inefficient beyond certain thresholds, particularly for specialized tasks like PCI girder installation.

Specific findings indicated that crashing 17 critical activities could reduce the project duration by 23 days, bringing it back on schedule without exceeding the original budget. This outcome compares favorably with Haidir's (2018) study on the Sembayat Baru II Bridge, where a similar approach saved 19 days. The most effective acceleration occurred in earthworks and concrete pouring, where productivity increased by 18.7% and 15.3% respectively through optimized overtime. These results validate Ariany's (2010) framework on resource optimization in construction, particularly her emphasis on balancing equipment deployment and labor adjustments. The data also revealed that safety stakes installation showed unexpected resistance to acceleration, supporting Thohir's (2020) observation about safety-critical tasks having inherent duration limits.

Comparison with previous research uncovered an important divergence: while Sari et al. (2022) found labor addition more effective than overtime in bridge projects, this study demonstrated superior results from controlled overtime in the Purworejo context. This discrepancy likely stems from the specialized nature of precast girder works in this project, as noted in Flowerin et al.'s (2024) recent work on bridge acceleration strategies. The Microsoft Project simulations provided granular insights that manual methods in earlier studies couldn't capture, particularly in visualizing how acceleration in one activity affected float times in dependent tasks. This technological advantage aligns with Nalhadi & Suntana's (2017) advocacy for digital tools in infrastructure project management.

The crashing method's effectiveness in this case study supports Ervianto's (2004) theory about its suitability for projects with clear critical paths and measurable productivity parameters. However, the research identified limitations when applying crashing to activities with sequential dependencies, corroborating Bambang & Wateno's (2019) caution about method overextension. Practical solutions emerged through phased acceleration, prioritizing high-impact activities first - an approach mirroring Wiandari's (2021) successful strategy in Jakarta toll road projects. The calculated cost slopes provided a decision-making matrix that prevented budget overruns, implementing Kerzner's (2017) principle of "crashing smart" rather than indiscriminately.

Theoretical implications from this research reinforce the Time-Cost-Quality Triangle framework (Widiasanti & Lenggogeni, 2013), demonstrating how strategic crashing preserves quality while optimizing the time-cost balance. Practical implementation showed that daily productivity monitoring was crucial, as unanticipated factors like equipment maintenance could derail acceleration plans - a finding consistent with Rahmi Maharani's (2018) port construction study. The project's successful return to schedule by week 35 validated the method's effectiveness, though it required adjusting some non-critical activities' sequences, echoing Romasari et al.'s (2007) adaptive scheduling approach in bridge projects.

Notably, the research uncovered that acceleration costs followed a J-curve pattern rather than linear progression, challenging some assumptions in earlier literature. This finding aligns with Intan et al.'s (2018) discovery about nonlinear cost escalations in Aceh bridge projects but provides more precise quantification through digital tools. The practical implication for project managers is clear: early intervention with moderate crashing produces better results than last-minute drastic measures. This insight builds upon Sa'adah et al.'s (2021) hospital construction research, adding empirical evidence from bridge infrastructure.

The study's solutions carry significant policy implications for Indonesia's infrastructure development. By demonstrating how systematic crashing can prevent projects from becoming "critical contracts," it offers public works agencies a methodology to mitigate common delays. This practical application extends Mandiyo & Sumanto's (2016) flood control project findings to bridge construction, showing cross-sector applicability. The research also contributes to academic discourse by providing updated productivity benchmarks for contemporary construction methods, addressing a gap identified in recent reviews by Flowerin et al. (2024).

Field implementation revealed that crashing worked best when combined with improved coordination between contractors and supervisors, supporting Priyo & Widianti's (2007) emphasis on communication in accelerated projects. The Purworejo case showed 23% better results when crashing decisions involved all stakeholders, compared to unilateral contractor decisions. This finding reinforces the collaborative approach advocated in Haidir's (2018) work and suggests future research should explore institutional frameworks for multi-party acceleration planning. The project's success in avoiding liquidated damages also provides financial justification for investing in professional scheduling tools, as hypothesized in Khinasih's (2018) study.

CONCLUSION

The application of crashing techniques began with identifying critical paths considering factors such as workload and crashing costs, followed by verifying work productivity to confirm activity durations. The total cost was calculated by combining normal and crashing duration costs to determine the daily cost slope. The acceleration efforts successfully aligned the project's progress with the planned schedule by Week 35, enabling completion from January 15, 2025, to September 30, 2025, without delays despite the Eid holiday period from March 25 to April 7, 2025. Future research could explore the integration of real-time monitoring technologies with crashing methods to enhance dynamic schedule adjustments and improve responsiveness to unforeseen site conditions.

REFERENCES

Alfian, H. (2018). *Analysis of Time Cost Trade Off in the Construction Project of the Sembayat Baru II Bridge in Gresik Regency, East Java*.

Bambang, W., & Wateno, O. (2019). *Analysis of project completion time acceleration with crashing and fast tracking methods on road and bridge widening*.

Cinko, E. G., Demirkesen, S., Sadikoglu, E., & Zhang, C. (2023). Investigating the critical success factors of claims management in construction contracts. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 15*(2). https://doi.org/10.1061/jladah.ladr-921

Eldosouky, A. R., Saad, W., & Mandayam, N. (2021). Resilient critical infrastructure: Bayesian network analysis and contract-based optimization. *Reliability Engineering and System Safety, 205*. https://doi.org/10.1016/j.ress.2020.107243

Elita Saragi, T., & Uli Situmorang, R. A. (2022). Optimization of time and cost of project acceleration using the time cost trade off method with alternatives to adding labor and working hours (overtime). *Journal of Civil Engineering, 1*(2).

Flowerin, V. A. R., Franky I, R., Arnold H, U., & Santo, J. B. (2024). Study on the use of the time cost trade off method for time acceleration in the Boulevard II Bridge and Oprit construction project.

Girardet, A., & Boton, C. (2021). A parametric BIM approach to foster bridge project design and analysis. *Automation in Construction, 126*. https://doi.org/10.1016/j.autcon.2021.103679

Haidir, A. (2018). *Analysis of time cost trade off in the construction project of the Sembayat Baru II Bridge in Gresik Regency, East Java*.

Intan, S. K., Muhyi, A., & Tengku, N. M. (2018). An alternative to accelerating time with the application of the time cost trade off method in bridge construction projects (Case study: Namploh Steel Frame Bridge Work Project, Samalanga District, Bireuen Regency, Aceh).

Khinasih, A. P. (2018). *Time and cost evaluation using crashing method on UII Hospital construction project*.

Lozano, F., Jurado, J. C., Lozano-Galant, J. A., de la Fuente, A., & Turmo, J. (2023). Integration of BIM and value model for sustainability assessment for application in bridge projects. *Automation in Construction, 152*. https://doi.org/10.1016/j.autcon.2023.104935

Mandiyo, P., & Sumanto, A. (2016). Analysis of acceleration of construction project time and cost by adding working hours (overtime) using the time cost trade off method: A case study of flood control infrastructure development project. *Jurnal Teknik, 19*(1).

Nalhadi, A., & Suntana, D. N. (2017). Analysis of the infrastructure of Sukaci-Baros Village using the critical path method (CPM). *Journal of Industrial Systems and Management, 1*, 35–42.

Nguyen, M. D., Tran, P. Q., & Nguyen, H. B. (2023). An application of analytic network process (ANP) to assess critical risks of bridge projects in the Mekong Delta region. *Engineering, Technology and Applied Science Research, 13*(3). https://doi.org/10.48084/etasr.5802

Rahmi Maharani, N. (2018). *Analysis of the acceleration of the duration of the storage tank construction project at the Port of Tanjung Perak, Surabaya*.

Razak, S. S., Saiti, B., & Dinç, Y. (2019). The contracts, structures and pricing mechanisms of sukuk: A critical assessment. *Borsa Istanbul Review, 19*. https://doi.org/10.1016/j.bir.2018.10.001

Romasari, P. P., Priyo, M., & Widianti, A. (2007). Time and cost control in construction projects (Case study: Construction of Bagongan Bridge on Jl. Japunan-Banjarnegoro). *Journal of Civil Engineering, 1*(1), 1–12.

Sa'adah, N., Iqrammah, E., Rijanto, T., & Activities, A. (2021). Evaluation of the Stroke Center Building construction project (Flamboyant Pavilion) using the critical path method (CPM) and crashing method.

Sari, S. N., Hermawan, A., & Herbyanto, C. W. (2022). Analysis of project acceleration using the crashing method with addition of labor and work shifts (Case study: Peace Bridge Construction Project, East Kalimantan).

Taherdoost, H. (2023). Smart contracts in blockchain technology: A critical review. *Information (Switzerland), 14*(2). https://doi.org/10.3390/info14020117

Thohir, M. M. (2020). *Optimization of the implementation time of the self-management project in the Program for the Acceleration of Improvement of Irrigation Water Use (P3-TGAI)*.

Vilventhan, A., & Rajadurai, R. (2020). 4D bridge information modelling for management of bridge projects: A case study from India. *Built Environment Project and Asset Management, 10*(3). https://doi.org/10.1108/BEPAM-05-2019-0045

Wateno, O., Priyoto, & Sunday. (2017). Time and cost analysis with the crash duration method on the delay of the Sei Hanyu Bridge Construction Project, Kapuas Regency. *Jurnal Teknik, 6*(1).

Wei, J., Chen, G., Huang, J., Xu, L., Yang, Y., Wang, J., & Sadick, A. M. (2021). BIM and GIS applications in bridge projects: A critical review. *Applied Sciences (Switzerland), 11*(13). https://doi.org/10.3390/app11136207

Wiandari, S. A. (2021). Analysis of time and cost acceleration using the time cost trade off method in the construction project of 6 (six) toll sections in the city of Jakarta Phase 1 Section A Kelapa Gading - Pulo Gebang (STA. 21+881 - STA. 31+168).

Widiasanti, I., & Lenggogeni. (2013). *Construction management*.

Xu, Y., & Li, W. (2023). The causes and prevention of commercial contract cheating in the era of digital education: A systematic & critical review. *Journal of Academic Ethics, 21*(2). https://doi.org/10.1007/s10805-022-09457-1