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Comparative Analysis of Cost and Time of Implementation of Precast and Cast in Situ Work Using the CPM (Critical Path Method) in the Purwosari – Malingmati Road Reconstruction Project in Bojonegoro Regency

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ABSTRACT:
Road infrastructure is a crucial element in supporting the mobility of goods and people, while also contributing to economic growth and community welfare. The Purwosari–Malingmati road reconstruction project in Bojonegoro Regency faces challenges related to limited time and budget, making the selection of an efficient construction method essential. This study aims to analyze the comparison of time and cost between precast and cast in situ methods using the Critical Path Method (CPM). The research method employed is quantitative, descriptive, and comparative. Data were obtained from project documents and field observations, then analyzed to calculate the realization duration and total cost of each method. Time analysis compared planned and actual durations, while cost analysis covered all direct and indirect components, including materials, labor, equipment, and supporting expenses. Comparisons were conducted on similar work units to ensure objectivity. The results show that the precast method completed the work in 17 days—faster than the cast in situ method, which required 18 days—with a critical path of 12 days. In terms of cost, precast amounted to Rp 4.87 billion, while cast in situ reached Rp 18.20 billion (273% more expensive). Non-critical activities in the precast method could be carried out in parallel, thereby increasing efficiency. The time acceleration of the precast method was recorded at 19%, while cost savings were significant compared to cast in situ. In conclusion, the precast method is more effective and efficient in the context of this project—both in terms of time and cost.
Keywords: *precast; cast in situ; critical path method*

INTRODUCTION

Road infrastructure is a vital element in supporting the mobility of goods and people, which in turn contributes to economic growth and improved community welfare. The Government of Indonesia, through various national development programs, continues to strive to improve the quality and quantity of road infrastructure to strengthen connectivity between regions, accelerate the distribution of goods, and open access to remote areas. However, road construction often faces challenges such as budget constraints, short implementation times, and diverse geographical and social conditions. These problems cause frequent project delays, cost overruns, and even a decrease in work quality (Adam et al., 2017; Famiyeh et al., 2017; Green et al., 2015; Larsen et al., 2016). Therefore, selecting a construction method that is efficient in terms of time and cost is crucial to ensure the success of road infrastructure projects.

In the implementation of road projects, two main methods are commonly used: the precast and cast in situ methods. The precast method involves producing concrete elements outside the project site (in a factory) before installing them at the construction site, while the cast in situ method involves casting directly at the project site. Each method has different characteristics, advantages, and limitations, so the selection should be tailored to the project's specific conditions, including the scale of work, resource availability, site accessibility, and target time and budget.

Various previous studies have attempted to compare the two methods in terms of implementation time and cost, yet significant gaps remain in understanding their performance under specific regional conditions and project constraints. Research by Kuswanto et al. (2023) used the Analytical Hierarchy Process (AHP) method to analyze road improvement projects in Kediri Regency and found that the precast method is superior in time efficiency, although it is slightly more expensive than the cast in situ method. Similar findings were reported by Agatha and Djatmiko (2024), who used Primavera P6 software to simulate the duration of a box culvert project and found that the precast method significantly reduced time, achieving an actual duration of 83 days versus 150 days planned, while the cast in situ method was more cost-effective but took longer.

Another study by Rozikin (2024) compared U-ditch precast structures with kali stone pair and showed that precast is faster to install, whereas kali stone pair is superior in terms of cost. This indicates that method selection should consider project priorities, whether time efficiency or budget efficiency. Pakiding (2022) also stated that using precast systems in flat construction can reduce work time by up to 30%, even though it requires greater costs. Meanwhile, Hudoyo et al. (2024) used the Earned Value method to evaluate road and bridge projects in the Batang Integrated Industrial Estate (KIT) and found that time and cost control is easier with a precast approach, although strict monitoring of deviations is still required.

From these studies, it can be concluded that the precast method is generally superior in time efficiency and result quality but has the shortcoming of relatively higher initial costs. In contrast, the cast in situ method is more economical in initial expenditure but is prone to delays due to weather conditions and other field variables. However, these studies reveal a critical research gap: most existing research focuses on urban projects or large-scale construction with optimal resource availability, while regional road projects in areas with distinctive geographical, climatic, and socio-economic characteristics remain underexplored. The specific conditions of regional projects—including limited access to advanced construction technology, budget constraints typical of local government projects, and unique environmental challenges—necessitate dedicated investigation to provide context-appropriate guidance for method selection. Therefore, method selection must be adjusted to the project's characteristics, available budget, and target completion time. There remains a critical need for more specific research in the context of regional road projects with distinctive environmental, social, and technical characteristics, particularly in areas where infrastructure development is constrained by local conditions.

The Purwosari–Malingmati road reconstruction project in Bojonegoro Regency is one such infrastructure project that requires comprehensive evaluation to select the most efficient construction method. This project presents a unique opportunity to examine method performance in a regional context characterized by moderate traffic volume, typical local government budget limitations, and environmental conditions representative of East Java's inland areas. This road plays a strategic role as a connecting route between sub-districts and supports local economic activities. Before reconstruction, the pavement surface was severely damaged with longitudinal and transverse cracks; the surface experienced wear and deformation; and the drainage system did not function optimally, resulting in waterlogging. The old pavement structure could no longer withstand increasing traffic loads, especially from heavy vehicles, making reconstruction necessary to restore the road's function according to applicable technical standards (Ahmed et al., 2015; Shtayat et al., 2020; Sun, 2016; Wang et al., 2021).

This study analyzes the comparison of time and cost efficiency between the precast and cast in situ methods in road reconstruction work using the CPM (Critical Path Method) (Farida & Anenda, 2022; Purba, 2020; Salih et al., 2025; Yaqin et al., 2023). The novelty of this research lies in its comprehensive examination of both methods within a regional road project context, combining detailed CPM analysis with extensive cost breakdowns specific to Bojonegoro's local conditions (Amin et al., 2025; Falashifah, 2019). Unlike previous studies that primarily focused on urban infrastructure or isolated comparisons of single parameters, this research provides an integrated analysis of time-cost performance while considering practical constraints faced by local government projects. Furthermore, this study uniquely documents actual implementation performance in a setting where both methods were employed simultaneously, allowing direct comparison under identical environmental and managerial conditions (Bondarouk & Mastenbroek, 2018; Gomez-Conde et al., 2019; Green et al., 2015). The CPM method was chosen for its ability to identify critical paths that determine the minimum project completion duration, providing a clear picture of activities with the greatest impact on time and cost. Through this analysis, a comprehensive understanding of each method's advantages and limitations is expected, offering stakeholders an objective basis for selecting the optimal implementation method from technical and economic perspectives.

In addition to providing practical benefits for project decision-making, this research is expected to contribute to the development of sustainable, efficient, and adaptive construction management practices for regional infrastructure needs. The findings will offer valuable insights for local government agencies in optimizing limited budgets while maintaining project quality and timeline adherence. Moreover, the detailed cost-time comparison framework developed here can serve as a replicable model for similar regional projects across Indonesia. Thus, the results are not only relevant for the Purwosari–Malingmati project but can also serve as a reference for other road projects in areas with similar geographical conditions, climate, and traffic loads. This research is also expected to advance the field of construction project management, particularly in time and cost optimization through appropriate method selection.

METHOD

This study was designed using a comparative quantitative approach, with the aim of analyzing and comparing the cost efficiency and implementation time between precast and cast in situ construction methods in the Purwosari-Malingmati Road reconstruction project in Bojonegoro

Regency. This approach was chosen because it allows researchers to objectively measure the differences in the performance of the two methods based on quantitative data obtained from project documents and field observations.

This research was carried out in Bojonegoro Regency, East Java Province, with the main location being on the Purwosari-Malingmati Road section, which is part of a road reconstruction project managed by local government agencies. The selection of this location is based on the relevance of the project conditions that apply two construction methods, namely precast and cast in situ, especially on the work of drainage channels, road shoulders, and other supporting structures.

The data collection procedure in this study is carried out gradually and systematically to obtain relevant and accurate information. The first stage begins with conducting a literature study to obtain a strong theoretical foundation related to precast and cast in situ construction. The next step is to make direct observations to the Purwosari-Malingmati Road project site in Bojonegoro Regency to document the real conditions on the ground. The secondary data needed is collected through official project documents, such as the Cost Budget Plan (RAB), implementation schedule, implementation methods, work drawings, daily reports of work, as well as data on work volume and price units.

The data analysis technique was carried out quantitatively, descriptively, and comparatively using the Critical Path Method (CPM) method. The data that has been collected from project documents and field observations is analyzed by calculating the total cost and duration of implementation time of each method. Cost analysis is carried out by summing all direct and indirect cost components, including material costs, labor, tools, and other supporting costs. Time analysis is carried out by comparing the time plan with the actual time of the work implementation, as well as identifying critical paths using CPM.

RESULTS AND DISCUSSION

Project Overview

The Purwosari-Malingmati Road Reconstruction Project is an activity to improve transportation infrastructure carried out by the Bojonegoro Regency Government as an effort to improve the condition of damaged roads and increase the capacity of traffic services in the Purwosari and Malingmati areas. This project is located in Purwosari to Malingmati District with a section length of 5,450 meters. The implementation of reconstruction uses two main methods for concrete structure work, namely the precast method for the installation of precast concrete slabs, and the cast in situ method for work that requires direct casting on site.

The existing conditions before reconstruction were generally in the form of pavement surfaces that experienced elongated and transverse cracks, surfaces experienced wear and deformation (rutting), drainage in some segments did not function optimally so that inundation occurred, and old pavement structures were no longer able to withstand increased traffic loads, especially heavy vehicles. This condition has caused a decrease in the level of road services, so reconstruction is a necessary step to restore road functions according to applicable technical standards.

Precast Job Time Performance Analysis

Based on CPM analysis, the critical path of precast work is in the sequence of activity P1→P2→P3→P4→P5, with a critical trajectory duration of 12 days and a total duration of work realization of 17 days. This critical path indicates that a delay in any of these activities will directly affect the overall duration of the precast job. Activities included in the critical pathway include precast mobilization (P1) with a duration of 2 days, area preparation (P2) with a duration of 2 days, bedding layer (P3) with a duration of 2 days, installation of precast slabs (P4) with a duration of 4 days, and alignment & leveling (P5) with a duration of 2 days.

The results of the study show that the precast method is able to speed up the implementation time because most of the concrete element production process is carried out in the factory. In the field, the work only includes the installation of precast units, position adjustment, splicing, and grouting, so that the process is simpler and the duration of implementation can be significantly shortened. Some of the factors that cause the duration of the work to be shorter include: the work can run stably without being too affected by the weather, there is no curing process that holds back the execution of the next activity, and some work can be carried out in parallel in a limited capacity, thus speeding up the overall duration of the project.

Table 1. Duration of Plan and Realization of Precast Work

Code	Activities	Plan Duration (days)	Duration of Realization (days)	Deviation
P1	Precast Mobilization	2	2	0
P2	Area preparation	3	2	-1
P3	Bedding layer	2	2	0
P4	Precast slab installation	5	4	-1
P5	Aligning & leveling	2	2	0
P6	Jointing	3	2	-1
P7	Grouting	3	2	-1
P8	Final inspection	1	1	0
	Total	21	17	-4

Table 1 shows the comparison of plan duration and realization for each precast work activity. From the table, several activities have accelerated, namely area preparation (P2), precast slab installation (P4), jointing (P6), and grouting (P7), each 1 day faster than planned. This acceleration occurred due to the increase in the number of workers, the rearrangement of workflows in the field, and the process of mobilizing precast elements that ran smoothly with the availability of adequate lifting equipment. Overall, the total duration of the realization of the precast work was 17 days, 4 days faster than the duration of the 21-day plan, which showed a time efficiency of 19%.

Cast In Situ Job Time Performance Analysis

Based on CPM analysis, the critical trajectory of cast in situ work is C1→C2→C3→C4→C5→C6, with a total realization duration of 18 days. This duration is longer than precast work because all stages must be done in the field sequentially, so it cannot be accelerated without adding risk to the quality of the work. Activities included in the critical path include formwork (C1) with a duration of 3 days, repetition (C2) with a duration of 3 days, concrete casting (C3) with a duration of 2 days, surface finishing (C4) with a duration of 1 day, curing concrete (C5) with a duration of 6 days, and dismantling of formwork (C6) with a duration of 2 days.

Some of the factors that cause the duration of cast in situ work to be longer include: formwork installation and repetition require significant time because it is manual and complex, the concrete curing process requires a minimum of 7 days for the concrete to reach the desired strength so that the next work cannot start faster, and the work is very sensitive to weather conditions where rain can cause delays. This condition makes the cast in situ method longer and more prone to delays than the precast method.

Table 2. Duration of Plan and Realization of Cast In Situ Work

Code	Activities	Plan Duration (days)	Duration of Realization (days)	Deviation
C1	Bekisting	4	3	-1
C2	Repetition	4	3	-1
C3	Casting	2	2	0
C4	Finishing	1	1	0
C5	Curing concrete	7	6	-1
C6	Formwork disassembly	2	2	0
C7	Quality check	1	1	0
	Total	21	18	-3

Table 2 shows a comparison of the duration of the plan and the realization for each cast in situ work activity. Some activities have accelerated, namely formwork (C1), repetition (C2), and concrete curing (C5), each 1 day faster than planned. The acceleration in C1 and C2 activities occurred due to the increase in the number of handymen and helpers as well as the optimization of work methods, while the acceleration in C5 occurred due to favorable weather conditions and the use of curing compounds that accelerate the concrete surface treatment process. Overall, the total duration of cast in situ realization is 18 days, 3 days faster than the plan duration of 21 days, showing that the implementation process can run efficiently with proper resource management.

Comparison of Precast and Cast In Situ Time Performance

Table 3. Comparison of Critical Duration of Precast and Cast In Situ Methods

Method	Critical Duration (days)	Differences	% Faster
Precast	17	-	-
Cast In Situ	18	+1 day longer	Precast ≈ 6% faster

Table 3 shows that the precast method has a critical duration of 17 days, while the cast in situ method requires 18 days, so there is a difference in duration of 1 day where the precast method is proven to be faster to complete. This difference shows that the work with the precast method is more time-efficient because most of the processes are already done in the factory, so the field work becomes shorter and more controlled. In other words, precast is about 6% faster than cast-in-situ. The precast time advantage is due to the fact that most of the structural elements are manufactured in the factory, so that the field work is limited to installation, splicing, and grouting which can be done faster and more stable than cast-in-situ work which is done entirely in the field sequentially and is greatly affected by weather conditions.

Precast Job Cost Performance Analysis

The cost analysis of precast work was carried out by summing up all cost components consisting of the main material in the form of precast U-Ditch of various sizes and welded wire mesh (WWM) as structural reinforcement. The total cost of precast work based on RAB reached IDR 4,867,814,447.38. The largest cost component comes from the standard WWM of IDR 4,349,376,336.89 and the unequal price WWM of IDR 257,855,207.49, as well as the precast U-Ditch of various sizes of IDR 260,582,903. The cost characteristics of precast suggest that this method is more efficient because mass fabrication is done in the factory, labor costs are relatively low due to minimal field work, and the volume of field work is limited to installation and finishing.

Table 4. Precast Job Cost Details

Item	Volume	Unit Price (Rp)	Amount (Rp)
U-Ditch Precast 600×600	21 m'	3.342.043	70.182.903
U-Ditch Precast 500×500	68 m'	2.800.000	190.400.000
WWM Standard	261,631.10 kg	16.624,08	4.349.376.336,89
WWM Unequal Price	17,222.49 kg	14.972,01	257.855.207,49
		Total	4.867.814.447,38

Table 4 shows the cost details of precast work consisting of precast U-Ditch of various sizes and welded wire mesh. The cost of precast materials is relatively high because the fabrication process in the factory requires equipment investment and strict quality control, but this is offset by the efficiency of on-the-ground execution which results in savings in labor, tool, and project overhead costs. The precast method also reduces the risk of material wastage because production is carried out to controlled standards.

Cast In Situ Work Cost Performance Analysis

The analysis of the cost of cast in situ work shows that the total cost is much higher than precast, which is Rp 18,202,605,739.85. This cost includes three main components, namely multi-quality structural concrete (fc 10, fc 20, fc 30 MPa) of IDR 11,678,123,808.12, reinforcing steel (BjTP 280 and BjTS 280) of IDR 3,777,364,887.23, as well as other structures such as pile foundations, concrete drill posts, stone pairs, and gabions of IDR 2,747,117,044.50. The cost characteristics of cast in situ indicate that this method requires large quantities of materials, high labor for manual work in the field, as well as the use of heavy equipment for a longer duration, so that overhead costs also increase.

Table 5. Cast In Situ Job Cost Details

Components	Amount (Rp)
Concrete fc 30 MPa	6.374.765.373,68
Concrete fc 20 MPa	2.604.250.637,50
Concrete fc 10 MPa	2.699.107.796,94
Subtotal Beton	11.678.123.808,12
BjTP 280	1.474.790.916,06
BjTS 280	2.302.573.971,17
Subtotal Reinforcement Steel	3.777.364.887,23
Other Structures	2.747.117.044,50
Total Cast In Situ	18.202.605.739,85

Table 5 shows the breakdown of the cost of cast in situ work which is dominated by the cost of structural concrete of various qualities and reinforcing steel. The high cost of this method is due to the large material requirements, labor-intensive work for formwork installation, manual repetition, casting, and concrete maintenance that takes a long time. In addition, additional structural work such as the foundation of drill posts and piles also adds a significant cost component. Longer execution durations cause daily overhead costs such as labor costs, equipment rental, and project management to be greater than the precast method.

Comparison of Precast and Cast In Situ Cost Performance

Table 6. Comparison of the Total Cost of Precast and Cast In Situ Methods

Method	Total Cost (Rp)	Differences	% More Expensive
Precast	4.867.814.447,38	-	-
Cast In Situ	18.202.605.739,85	+13.334.791.292,47	273% more expensive

Table 6 shows the comparison of the total project implementation costs between the precast and cast in situ methods. Based on data, the total cost for the precast method is IDR 4,867,814,447.38, while the total cost for the cast-in-situ method reaches IDR 18,202,605,739.85, more expensive IDR 13,334,791,292.47 or around 273% than the precast method. This very significant cost difference is caused by several main factors, including the high need for materials and wet work in the cast in situ method, the longer duration of the implementation so that overhead costs increase, and the more intensive use of human resources and equipment in the field. These results show that the precast method is not only more time-efficient, but also much more cost-effective, making it a more economical alternative to construction projects of similar scale and complexity.

The results show that the precast method has significant advantages in terms of time and cost compared to the cast in situ method. In terms of time, the precast method is able to complete the work faster because most of the production process is done in the factory, so the work in the field is only limited to installation, position adjustment, splicing, and grouting. This reduces dependence on weather conditions and speeds up the overall duration of implementation. CPM analysis showed that the precast critical path had a duration of 17 days with a P1→P2→P3→P4→P5 trajectory, while the cast in situ critical path reached 18 days with a C1→C2→C3→C4→C5→C6 trajectory, showing a precast time efficiency of about 6%.

In terms of cost, although the initial cost of procuring precast elements is relatively high, the efficiency of on-the-ground implementation results in significant savings in the cost of labor, tools, and project overhead. The total cost of precast reached IDR 4,867,814,447.38, much lower than cast-in-situ which reached IDR 18,202,605,739.85 or 273% more expensive. The cast-in-situ method costs much more because all stages of work are carried out on the project site, including formwork installation, manual repeating, casting, curing, and dismantling of formwork, all of which take longer and more resources. The cost of materials in situ casts is also higher because it includes concrete of various grades (fc 10-30 MPa), large quantities of reinforcing steel, as well as supporting structures such as drilled post foundations and piles.

CPM analysis showed that cast-in-situ critical paths are longer and have more inter-activity dependencies than precasts. Any delay in critical activities will instantly extend the total duration of the project and increase the daily cost of the project. Activities such as curing concrete in situ require a minimum of 6-7 days and cannot be accelerated without sacrificing the quality of the structure, while in precast there is no curing activity in the field because the process has already been carried out in the factory. Thus, the precast method provides advantages not only in terms of time but also in terms of cost savings, especially in projects with high sensitivity to execution duration.

The findings of this study are in line with the results of previous research by Kuswanto et al. (2023), Agatha and Djatmiko (2024), and Rozikin (2024) which showed that the precast method is generally superior in time efficiency than cast-in-situ. However, this study makes an additional contribution by presenting more comprehensive cost comparison data in the context of regional road projects in Bojonegoro Regency, which shows that precast is not only faster but also much more economical with a cost difference of up to 273%. These results provide strong practical implications for decision-making in the selection of construction methods, especially for local government projects with budget constraints and tight time targets.

CONCLUSION

The analysis using the Critical Path Method (CPM) on the Purwosari–Malingmati Road reconstruction project demonstrates that the precast method outperforms the cast in situ method, completing the project in 17 days (versus 18 days, a 6% acceleration) at a total cost of IDR 4,867,814,447.38—substantially lower than the IDR 18,202,605,739.85 (273% more expensive) for cast in situ. CPM reveals shorter critical paths and parallel non-critical activities in the precast approach, enhancing overall efficiency and making it ideal for time- and budget-constrained regional projects. For future research, scholars should expand comparisons to include more than two methods, incorporate variables like labor productivity, weather, and site conditions, integrate tools such as PERT or Earned Value Management (EVM) for risk assessment, and replicate studies across diverse construction projects to enable broader generalizations on method effectiveness.

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