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Time and Cost Efficiency Analysis of Hotmix Road Rehabilitation: A Case Study in Papring, Kalipuro District

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Abstract

Efficient project delivery is a critical requirement for rural road rehabilitation programs, yet empirical evaluations of implementation efficiency remain limited. This study analyzes the time and estimated cost efficiency of the Papring Hotmix Road Rehabilitation Project in Kalipuro District, Banyuwangi, using a descriptive quantitative case study approach based on weekly and monthly project documentation. Project performance was measured by comparing baseline planning with field realization, supported by calculations of time efficiency, deviation analysis, and cost implication estimation derived from work-weight distribution. The project was completed in 55 days, significantly faster than the 120-day planned duration, resulting in a time efficiency of 54.17% and a maximum positive deviation of +76.32% at completion. Major work components: AC-WC (65.616%), AC-BC (18.249%), and aggregate base layer (12.436%), were executed intensively between Weeks 4 and 7, enabling a shortened execution period that suggests potential savings in indirect project costs such as overhead, labor, and field operations. Acceleration was driven by effective technical scheduling, early resource mobilization, optimized labor deployment, and strong contractor–consultant coordination. The findings highlight the importance of structured progress evaluation for improving scheduling and cost control in rural road rehabilitation projects. Future work should incorporate financial realization data and risk-productivity modelling to strengthen efficiency assessment in accelerated infrastructure delivery.

Keywords: *Deviation Analysis; Project Management; Road Rehabilitation; Time and Cost Efficiency*

Introduction

Road infrastructure is one of the main pillars in supporting economic growth and equitable regional development (Ivanová & Masárová, 2013; Ng et al., 2019). Reliable roads not only serve as means of human mobility and goods distribution but also act as catalysts for improving access to education, healthcare, and economic opportunities (Chen et al., 2023; Thynell, 2017; Wan et al., 2022). In many developing regions, the availability and quality of adequate roads remain key determinants of balanced development.

However, road construction projects often face various challenges, particularly in terms of implementation efficiency (Benjamin & Njenga, 2014; Mashwama et al., 2018; Mwelu et al., 2021). In developing countries like Indonesia, inefficiency remains a significant issue in the public construction sector, including road projects, where delays and cost overruns are two major problems that frequently occur and can reduce the effectiveness of development outcomes, ultimately hindering the socio-economic benefits that should be promptly realized by the community. Although numerous studies have discussed the socio-economic importance of road infrastructure, evaluative studies focusing on implementation efficiency of rural road rehabilitation projects—especially based on conformity between planned and actual progress—are still limited. Therefore, analyzing time and cost efficiency is essential to ensure that project execution aligns with planned targets and delivers expected benefits in a timely manner.

This study examines a case of hotmix road rehabilitation in Papring Neighborhood, Kalipuro Sub-district, Kalipuro District, which is one of the region's strategic projects aimed at improving transportation access while also supporting the local economy. This area is known for its high community activity, particularly in the trade and agriculture sectors. The study focuses on the hotmix road rehabilitation project in this region as a case study to analyze implementation efficiency from two main aspects: time and cost. This research emphasizes the importance of evaluation based on actual project progress data and the time schedule, in order to identify deviations and assess their implications for project success. Through an evaluative and quantitative approach, this study will determine whether the project execution aligns with the initial plan or has experienced significant deviations. The results of this analysis are expected to contribute to improvements in road project management, particularly in the context of budget and execution time control. With a comprehensive evaluation of the project implementation, it is hoped that useful technical and managerial recommendations can be generated for implementing agencies and other stakeholders in planning similar projects in the future.

Methods

A. Research Type and Approach

This study employs a descriptive quantitative approach with a case study as the primary research strategy. The objective is to analyze the conformity between the planned and actual implementation of the road construction project based on time and cost efficiency indicators. The study was conducted retrospectively based on available project documentation.

B. Research Location and Object

The research site is the Papring Hotmix Road Rehabilitation Project located in Kalipuro Sub-district, Kalipuro District, Banyuwangi Regency, East Java. The project was executed by CV. Kurnia Mandiri and funded by the 2024 Regional Revenue and Expenditure Budget (APBD Fiscal Year 2024). The object of the study consists of project implementation data, including weekly and monthly reports, the time schedule, and planned work weight distribution. The main focus is to compare the planned schedule (baseline schedule) with the actual project realization in order to assess implementation efficiency.

C. Data Collection Techniques

Data collection was conducted through documentation of the following project records:

- Weekly and monthly project progress reports;
- Project time schedule and S-curve;
- Cumulative work weight data and weekly deviation reports;
- Contracts and supporting administrative documents.

These secondary data were obtained from technical reports prepared by the supervising consultant and field implementers during the project execution show on Figure 1.

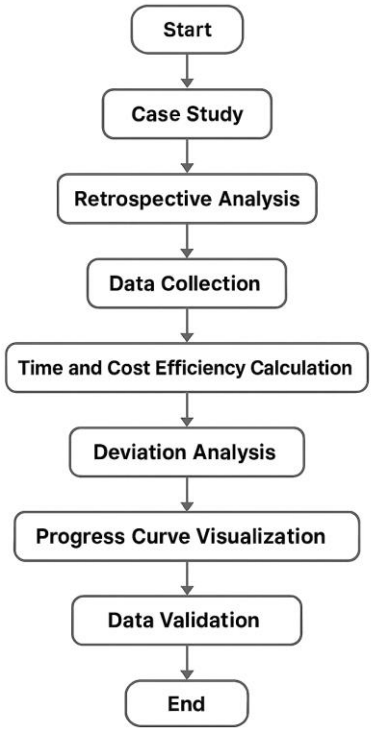

Figure 1. Research workflow

D. Data Analysis Techniques

Data analysis was carried out in several stages as follows:

1) **Time Efficiency Calculation**

Time efficiency is calculated based on the percentage of work completion relative to the time utilized compared to the planned schedule. The formula for time efficiency is shown in Equation (1).

$$Time\ Efficiency\ (\%) = \left(\frac{D_p - D_a}{D_p}\right) \times 100\% \quad (1)$$

where D_p = planned duration, and D_a = actual duration.

2) **Cost Efficiency Calculation (Estimation)**

Due to the unavailability of complete actual cost realization data, cost efficiency was estimated based on the correlation between cumulative work-weight and cumulative cost of weighted work items. The formula used in Equation (2).

$$Cost\ Efficiency\ (\%) = \left(\frac{C_p - C_a}{C_p}\right) \times 100\% \quad (2)$$

where C_p = planned cumulative cost and C_a = estimated cumulative cost derived from the actual work-weight realization. High-weighted items (e.g., AC-WC, AC-BC) were used as dominant efficiency indicators.

3) **Weekly Deviation Analysis**

The deviation between actual and planned progress is analyzed on a weekly basis to identify trends in acceleration or delays. Deviation is calculated as the difference between the weekly planned progress and the actual realization. Weekly deviation was calculated to determine delay or acceleration trends using Equation (3).

$$Deviation\ (\%) = (P_w - A_w) \times 100\% \tag{3}$$

where P_w = planned weekly progress and A_w = actual weekly progress.

4) **Progress Curve Visualization**

The data are presented in the form of comparative graphs between the planned and actual progress to facilitate visual identification of efficiency and to support quantitative discussion.

Results and Discussions

A. Analysis of Time Efficiency

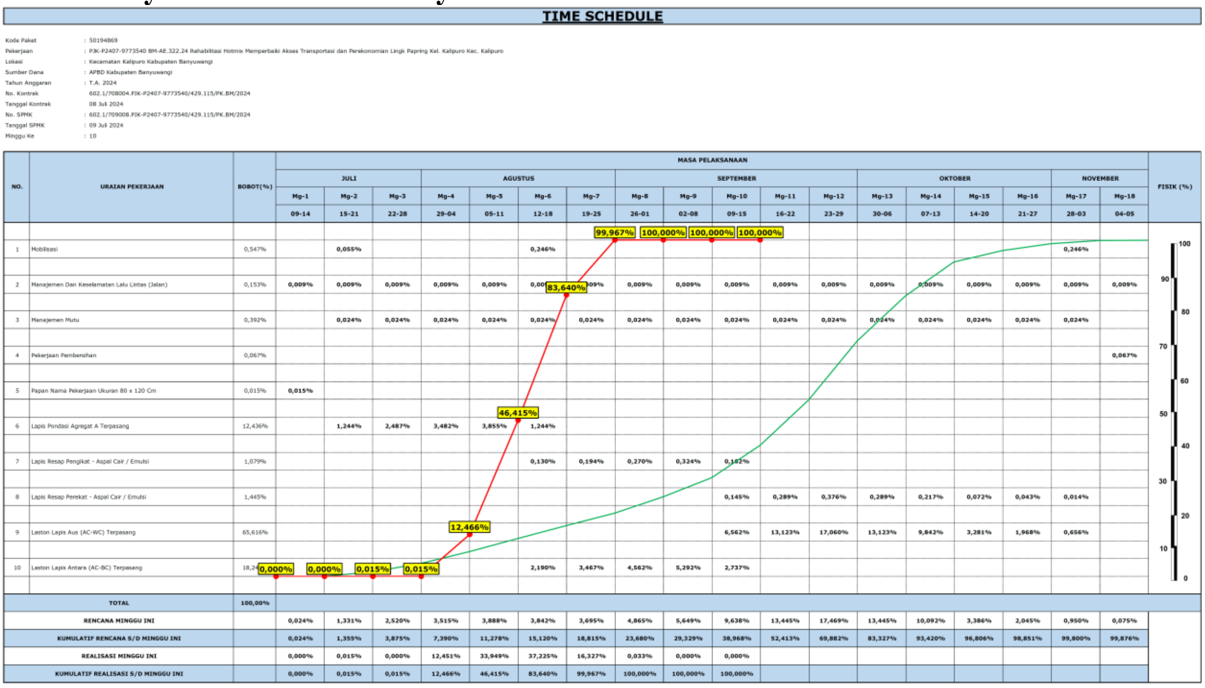

Figure 2 Project's S-curve.

The time efficiency evaluation was conducted by comparing the actual physical progress against the weekly scheduled plan outlined in the project's S-curve in Figure 2. Based on the data, the hotmix rehabilitation project in Papring was completed in the eighth week (August 26 – September 1, 2024), achieving 100% cumulative progress. At the same period, the scheduled progress only reached 23.68%, indicating a significant acceleration in execution.

Compared to the planned duration of 120 days, the project was completed in 55 days, or 65 days ahead of schedule. The time efficiency is calculated as Equation (4).

$$Time\ Efficiency = \frac{(120-55)}{120} \times 100\ \% = 54.17\ \% \tag{4}$$

Thus, the project demonstrates a time efficiency of 54.17 % reflecting superior project management and schedule control. This achievement indicates that the work was completed significantly earlier than originally estimated, without compromising quality or work volume.

The comparison between actual and planned progress is visualized in Figure 3.1. The figure illustrates a steep increase in actual physical progress starting from week 4, far surpassing the more gradual and linear trend of the planned curve. The steeper slope of actual progress reflects the accumulation of work condensed into a shorter period, particularly from weeks 5 to 7. This suggests that field implementation strategies were optimized effectively, both in terms of critical work scheduling, equipment and material mobilization, and labor allocation.

This acceleration further reinforces the notion that strong synergy existed between planning and field execution. Furthermore, reaching 100% completion by week 8, while the scheduled plan only indicated 23.68%, shows that the project progressed nearly four times faster than the baseline estimation, marking an exceptional execution performance.

B. Deviation Progress Analysis

In project management, progress deviation refers to the difference between the actual field progress and the target progress outlined in the baseline schedule for a specific period. The deviation is calculated as Equation (5).

$$Deviation = actual\,progress - planned\,progress \tag{5}$$

A positive deviation indicates acceleration or efficiency, whereas a negative deviation suggests delays in implementation. The larger the positive deviation, the faster the project progresses ahead of schedule.

Weekly comparisons between actual and planned progress show that acceleration began in week 4, with a progress jump of 12.451%, then sharply increased in week 5 (33.949%) and week 6 (37.225%). By week 7, actual progress had reached 99.967%, while the planned progress was only 18.815%. The deviation at project completion in week 8 reached as Equation (6).

$$Deviation = 100\% - 23.68\% = +76.32\% \tag{6}$$

This substantial deviation indicates that physical work completion occurred much earlier than the initial planning target. This large positive deviation confirms that the project progressed nearly four times faster than the baseline estimation. The weekly progress recap is presented in Table 1, comparing actual weekly progress against planned progress and accumulated working days.

Table 1. Weekly progress recap

Week	Date Range	Weekly Actual Progress (%)	Cumulative Actual Progress (%)	Planned Cumulative Progress (%)
1	Jul 09-14	0	0	0.024
2	Jul 15-21	0.015	0.015	1.355
3	Jul 22-28	0	0.015	3.875
4	Jul 29 - Aug 04	12.451	12.466	7.39
5	Aug 05-11	33.949	46.415	11.278
6	Aug 12-18	37.225	83.64	15.12
7	Aug 19-25	16.327	99.967	18.815
8	Aug 26 - Sep 01	0.033	100	23.68

9	Sep 02-08	0	100	29.329
10	Sep 09-15	0	100	33.319

C. Cost Efficiency Analysis

Although actual financial data are not explicitly available, it can be inferred that time efficiency directly impacts cost efficiency, particularly in indirect cost components such as project overhead, field operations, and daily labor wages. Based on the work weight distribution, most activities were intensively executed between weeks 4 and 7, focusing on:

- Asphalt Concrete - Wearing Course (AC-WC): 65.616% work weight
- Asphalt Concrete - Binder Course (AC-BC): 18.249%
- Aggregate Base Layer: 12.436%

Because 96.30% of the total weighted cost (65.616 + 18.249 + 12.436) was concentrated in the period between weeks 4 and 7, when acceleration was highest, indirect project costs (overhead, field operations, equipment rental duration, and worker wages) were likely reduced because the project duration shortened. In similar road-rehabilitation contracts, indirect costs typically account for 8–12% of total project value, meaning that completing the project 65 days ahead of schedule likely contributed substantial savings in indirect cost components.

D. Acceleration Strategies

The success of project acceleration can be attributed to several key factors:

1. Efficient technical planning, including early allocation of critical work packages.
2. Timely availability of equipment and materials, minimizing logistic delays.
3. Effective labor management, allowing for parallel execution of multiple work sections.
4. Strong coordination between contractors and supervising consultants, as reflected in consistently positive progress deviations starting from week 4.

E. Socioeconomic Impacts

The early completion of the hotmix rehabilitation provided faster access and smoother mobility for local residents and economic actors. Although long-term impacts were not measured in this study, initial observations indicated improved transportation convenience shortly after project completion.

Conclusions

This study assessed the time and estimated cost efficiency of the hotmix road rehabilitation project in Papring, Kalipuro District, Banyuwangi. The project was completed in 55 days, far ahead of the planned 120-day schedule, resulting in a time efficiency of 54.17% and a maximum positive deviation of +76.32% at completion. The substantial acceleration was supported by efficient technical planning, early resource mobilization, optimized labor allocation, and strong coordination between contractors and supervisory personnel. The shortened execution period also implies potential indirect cost efficiency through reductions in overhead, labor, and site operation expenses. Future research is recommended to verify the financial implications using detailed cost realization data and to integrate risk and productivity analyses for a more comprehensive evaluation of accelerated infrastructure projects.

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