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Comparative Analysis of Planned and Actual Progress in Road Projects Using Schedule Performance Index

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Abstract: This study aims to evaluate the time performance of the Teratak – Muara Kaman Ilir Road Reconstruction Project by comparing planned and actual cumulative progress using the Schedule Performance Index (SPI). The research employs a descriptive quantitative method with a single case study approach on a district-funded road project in Kutai Kartanegara Regency, Indonesia. Weekly progress data were analyzed over a 16-week execution period. Results show the lowest SPI occurred in week 4 at 0.170, while the highest SPI was recorded in week 7 at 3.663. The SPI trend graph indicates a fluctuating pattern, with delays in early weeks, significant acceleration in the middle phase, and stabilization toward project completion. The SPI returned to 1.000 in week 16, indicating on-time project completion. These findings highlight that schedule recovery strategies effectively brought project execution back on track. However, the sharp fluctuation in SPI also suggests the need for more consistent and sustainable schedule control. The study confirms that SPI is a useful tool for time monitoring in construction projects, though it should be integrated with qualitative analysis to better understand the underlying causes of performance deviations:

Keywords: Project Management; Schedule Performance Index; Time Evaluation

1. Introduction

Road construction projects are a crucial component of infrastructure development that supports economic growth and regional connectivity (Tzonevska, 2023). However, in practice, many road projects encounter delays due to deviations between planned progress and actual progress in the field (Kumar & Kumari, 2025; Xue et al., 2021). These discrepancies not only affect technical performance but also lead to cost overruns and disruption of public services (Rahmah, 2025). To evaluate the effectiveness of project implementation from a time perspective, a performance indicator is needed to systematically monitor actual achievements against predetermined targets.

One widely used method to assess schedule efficiency in project execution is the Schedule Performance Index (SPI) (He et al., 2022; Moslehabadi, 2020), which represents the ratio between the value of work actually completed and the value of work that was planned at a given time (Janshar et al., 2025). SPI is a core component of the Earned Value Management (EVM) approach (Muharremi, 2025), which has been extensively adopted in construction project management (Elsaid et al., 2025). Several studies, such as those by Abdel Azeem et al. (2014), Le-Hoai et al. (2013), and Sackey & Kim (2019), have shown that SPI-based analysis can help identify potential delays at an early stage and provide a quantitative basis for project control decision-making.

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Based on this context, the present study aims to evaluate the time performance of the Teratak – Muara Kaman Ilir Road Reconstruction Project in Kutai Kartanegara Regency. The evaluation is carried out by comparing weekly cumulative planned and actual progress recorded in the project's schedule progress reports. The objectives of this research are to calculate the SPI values for each week of implementation, analyze the causes of deviations between plan and actual progress, and provide recommendations for data-driven schedule control strategies in road construction projects. The findings of this study are expected to contribute to the improvement of time monitoring and control systems in similar infrastructure projects in the future.

2. Materials and Methods

2.1. Research Location

This study was conducted on the Teratak – Muara Kaman Ilir Road Reconstruction Project, located in Muara Kaman District, Kutai Kartanegara Regency, East Kalimantan Province, Indonesia. The area is a rural region with limited connectivity access, making the road highly essential in supporting the community's economic activities, particularly in the distribution of agricultural, plantation, and freshwater fishery products. This road segment also serves as a vital link between regions, facilitating daily mobility for residents to access education and healthcare services. Therefore, this road infrastructure project holds strategic value within the context of village-based regional development.

Figure 1. Study Location.

The existing condition of the road prior to reconstruction was classified as severely damaged, with uneven surfaces, non-functioning drainage, and frequent flooding during the rainy season. In response, the local government allocated a budget of IDR 4,254,705,155 (excluding VAT) through the 2024 Regional Revenue and Expenditure Budget (APBD) to fund the road reconstruction. Given the challenging project environment such as the remote location and wet tropical climate this project serves as an appropriate case study for analyzing implementation efficiency, particularly in terms of time performance.

2.2. Type of Research and Approach

This research adopts a descriptive quantitative method with a single case study approach (Sugiyono, 2019). This approach allows the researcher to conduct an in-depth and contextual analysis of a specific project (Lennie & Tacchi, 2013, pp. 133–134). The main objective is to evaluate the efficiency of project implementation from a time management perspective using a performance-based measurement method, specifically the Schedule Performance Index (SPI).

In construction projects, delays are often a critical issue as they can lead to cost overruns, stakeholder conflicts, and quality degradation due to unplanned acceleration. Therefore, a quantitative approach is employed to ensure that time progress can be measured objectively based on numerical data recorded periodically throughout the project's execution. This method has been widely used in project evaluation

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studies. As stated by Abdel Azeem et al. (2014) and Le-Hoai et al. (2013), the SPI approach can assist in detecting schedule deviations at an early stage, thus enabling more timely and effective project control.

2.3. Data Sources and Types

The primary data used in this study were obtained from the Weekly Schedule Progress Document of the Teratak – Muara Kaman Ilir Road Reconstruction Project, provided in PDF and Excel formats by the project contractor. The document covers a 16-week project implementation period, from May 27, 2024 to September 23, 2024, and includes detailed weekly progress data consisting of:

- Percentage weight of each work item,
- Planned weekly progress percentage,
- Actual weekly progress percentage,
- Planned and actual cumulative progress (%),
- Weekly deviations between plan and actual.

The types of work listed in the document include key elements in road construction, such as Class B aggregate base layers, lean concrete subbase layers, and rigid pavement with 3.8 MPa cement concrete, as well as safety-related components such as banners, helmets, vests, and warning signs. All these components were analyzed based on their respective weights within the overall project progress.

The data were organized in weekly tabular format to allow for graphical visualization and performance indicator calculation, in accordance with fundamental principles of modern construction project control (PMI, 2017). The planned progress serves as the baseline reference, while the actual progress represents the real conditions in the field, which are compared against the plan for performance evaluation.

2.4. Data Analysis Method

The analysis was conducted using the Earned Value Management (EVM) approach, focusing on the Schedule Performance Index (SPI) indicator. SPI is a key metric used to measure the time efficiency of project execution by comparing the value of work actually completed (EV) with the value of work that was planned (PV) at a given point in time. The formula used is as follows:

$$\boldsymbol{SPI = \frac{EV}{PV}} \tag{1}$$

Where:

- EV (Earned Value): The value of work actually completed up to week n, calculated based on the cumulative actual progress.
- PV (Planned Value): The value of work that should have been completed by week n, according to the cumulative planned schedule.

The interpretation of SPI values is as follows:

- SPI = 1: The project is on schedule.
- SPI < 1: The project is behind schedule.
- SPI > 1: The project is ahead of schedule.

Additionally, cumulative weekly progress deviations were calculated using the following formula:

[*Deviation (%) = Cumulative Actual Progess (%) – Cumulative Planned Progress (%)*] (2)

These deviation values are used to identify critical weeks where significant discrepancies occur between planned targets and actual outcomes. Both SPI and deviation indicators are utilized to develop trend graphs and comparative tables. The calculations and visualizations were performed using Microsoft Excel due to its capabilities in handling numerical data, generating line and bar charts, and facilitating easy verification of computations. Excel has proven to be a reliable tool in infrastructure project reporting (Shi, 2025).

3. Results

3.1. Cumulative Planned and Actual Progress

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Based on the weekly progress data of the Teratak – Muara Kaman Ilir Road Reconstruction Project, it is known that the project commenced in the first week with a planned cumulative progress of 0.46%. The planned targets gradually increased week by week, reaching 100% by the 16th week. On the other hand, actual field progress was also recorded weekly and showed a pattern that did not always align linearly with the plan.

Up to the second week, the implementation proceeded according to schedule, with actual progress values matching the planned ones (0.46% and 0.63%). However, in the third and fourth weeks, there was a significant decline in actual progress, reaching only 0.65% and 0.67% compared to the planned targets of 1.96% and 3.95%, respectively. This indicates an early-stage delay in the project execution.

The peak of positive deviation occurred from week 6 to week 10, during which the cumulative actual progress significantly exceeded the planned targets. This period can be interpreted as a phase of accelerated work. For example, in week 6, actual progress reached 37.22% while the planned target was only 10.54%. However, after week 10, the gap between planned and actual progress began to narrow, indicating that the rate of acceleration had slowed toward the end of the implementation period.

3.2. Schedule Performance Index (SPI) Calculation

To evaluate the efficiency of project time performance, the Schedule Performance Index (SPI) was calculated weekly using the formula SPI = EV / PV, where EV (Earned Value) represents the cumulative actual progress, and PV (Planned Value) represents the cumulative planned progress.

The results of the weekly SPI calculations are presented in the following table:

Table 1. Schedule Performance Index (SPI) Calculation Results.

Week	Planned Cumulative Progress (%)	Actual Cumulative Progess (%)	SPI
W1	0.46	0.46	1.000
W2	0.63	0.63	1.000
W3	1.96	0.65	0.332
W4	3.95	0.67	0.170
W5	6.59	15.62	2.370
W6	10.54	37.22	3.531
W7	14.99	54.89	3.663
W8	20.81	72.74	3.495
W9	27.79	78.73	2.833
W10	35.58	84.72	2.381
W11	43.37	84.74	1.954
W12	55.92	84.76	1.516
W13	71.60	87.78	1.226
W14	87.28	92.30	1.057
W15	96.69	99.83	1.032
W16	100.00	100.00	1.000

From the table above, it can be observed that:

- SPI values less than 1 in weeks 3 and 4 indicate project delays,
- SPI values greater than 1 from weeks 5 to 15 suggest accelerated work progress,
- An SPI value of 1 in week 16 indicates that the project was completed on schedule.

The highest SPI value was recorded in week 7, reaching 3.663, which signifies that during that week, project execution was more than three times faster than the planned schedule.

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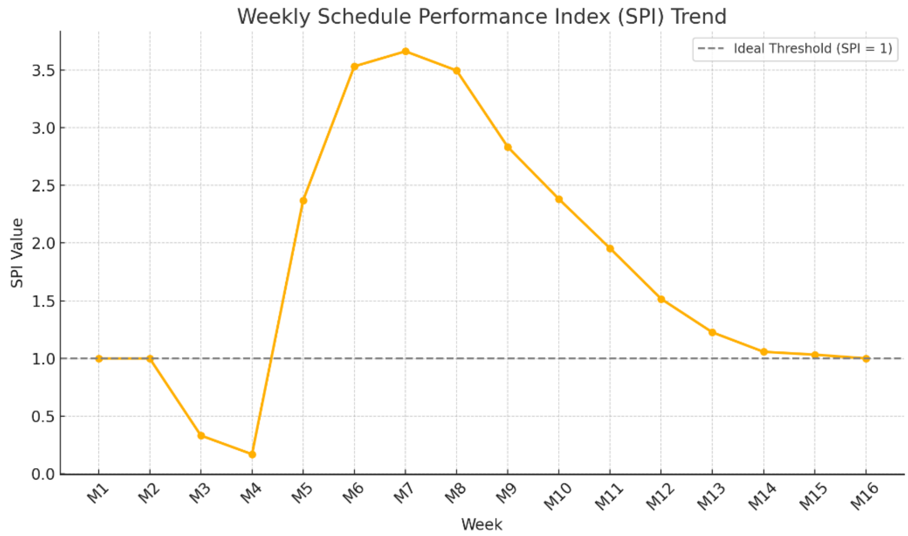

Figure 2. Weekly Schedule Performance Index (SPI) Trend Graph

It can be seen that the SPI values dropped below 1 in weeks 3 and 4, indicating a delay in project execution. However, starting from week 5, a significant acceleration occurred, with SPI values rising above 2 and peaking in week 7 at SPI = 3.663. After week 10, the SPI trend began to decline but remained above the ideal threshold of 1.0, and finally stabilized at SPI = 1.000 in week 16.

3.3. Interpretation of Results

The calculation results indicate that although the project experienced delays during the initial weeks of execution, it was successfully recovered and even performed ahead of schedule in the subsequent weeks. This may have been driven by acceleration strategies, additional resource allocation, or improvements in construction methods and efficiency.

However, such significant acceleration within a short period should be further examined in terms of work quality and safety. Hasty execution in construction projects often introduces risks related to quality control and coordination between work activities. Overall, the SPI values most of which were above 1 demonstrate that the project was generally time efficient. Nonetheless, the week-to-week fluctuations in SPI suggest that schedule control was not consistently maintained, highlighting the need for balanced strategies between speed and sustainable work pacing.

4. Discussion

The calculated values of the Schedule Performance Index (SPI) reveal a dynamic and fluctuating execution pattern throughout the project (Malingkas, 2025). In the early weeks, the project progressed as planned (SPI = 1), but then experienced a sharp decline in weeks 3 and 4, indicating a schedule delay. This was followed by a remarkable acceleration phase, as shown by the SPI values rising significantly above 2 and peaking at 3.66 in week 7. This trend reflects the implementation of aggressive schedule recovery strategies, such as increasing labor, extending work hours, or accelerating work methods .

Such extreme acceleration is consistent with the findings of Abdel Azeem et al. (2014), but it should be treated with caution as it may pose risks to work quality and safety if not accompanied by proper quality control. After reaching its peak, the SPI gradually decreased but remained above 1 until the project was completed in week 16. This indicates that the project ultimately met its time objectives, despite inconsistencies in week-to-week execution. According to PMI (2017), maintaining sustainable schedule performance is more desirable than uncontrolled bursts of acceleration.

Overall, the use of SPI has proven effective in monitoring project time efficiency. However, since SPI is a quantitative metric, it does not directly explain the underlying causes of schedule deviations. Therefore, future research is recommended to combine SPI analysis with qualitative data, such as field interviews or

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project risk assessments, to gain a more comprehensive understanding of the causes of delays and successful schedule recovery in construction projects.

5. Conclusions

This study aimed to evaluate the time efficiency of the Teratak – Muara Kaman Ilir Road Reconstruction Project by comparing planned and actual cumulative progress using the Schedule Performance Index (SPI) as the main indicator. The SPI calculations revealed that the project's time performance fluctuated significantly throughout its execution. The lowest SPI was recorded in week 4 at 0.170, indicating a severe delay. In contrast, an extreme acceleration occurred starting from week 5, with the SPI peaking at 3.663 in week 7, reflecting a work rate more than three times faster than planned.

After week 10, the SPI trend gradually declined yet remained above the ideal threshold (SPI > 1) up to week 15, and eventually stabilized at SPI = 1.000 in week 16, signifying that the project was completed on schedule. These findings indicate that although initial schedule deviations occurred, the schedule recovery strategies implemented were successful in realigning the project with its original plan. This highlights the importance of regular progress monitoring and swift managerial response to time-related deviations in construction projects

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