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Analysis of Cost and Schedule Variances Using Earned Value Method on Waru - Buduran Frontage Road Bridge Construction Project

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ABSTRACT
Infrastructure development is an important element in supporting economic growth, including in Indonesia. The Waru - Buduran Frontage Road Bridge development project was designed to overcome traffic congestion in the Sidoarjo area as a buffer zone for Surabaya. However, the project faced various obstacles, including schedule deviations and significant costs. This research aims to analyze the project's cost and schedule performance using the Earned Value Analysis method, focusing on Schedule Variance and Cost Variance to identify the main causes of delays and cost inefficiencies and provide recommendations for improvement. The research method used was a descriptive quantitative approach, with data collection through documentation of project financial reports, weekly schedules, and interviews with project managers. The analysis was carried out by calculating EVA indicators, such as Planned Value, Earned Value, and Actual Cost, to evaluate the cost efficiency and timeliness of the project. The results showed that the project experienced a negative schedule deviation of -9.911% in the 14th week, caused by technical constraints in utility relocation and coordination between stakeholders. However, the project still showed cost efficiency with a positive Cost Variance of 3.8%, indicating that actual costs were lower than the planned budget. The implications of this research highlight the need for more effective schedule planning, improved project coordination, and the implementation of acceleration strategies to reduce the impact of delays. In addition, the integration between schedule and cost management must be improved so that cost efficiency does not compromise the continuity of the project schedule.

Keywords: Construction Project Management, Cost Variance, Earned Value Method, Frontage Road Project, Schedule Variance.

INTRODUCTION

Infrastructure development is an important element in supporting the economic growth of a country, including Indonesia. Sidoarjo Regency, which acts as a buffer zone to Surabaya, has shown an urgent need to improve transportation connectivity to support industrial and trade activities. The Waru—Buduran Frontage Road and Bridge project was designed to address traffic congestion issues in this key corridor.

However, like many other infrastructure projects, it faced several schedule and cost constraints. The main constraints included delays in removing utilities, such as electricity and

telecommunication poles, which resulted in a progress deviation of -9.911% at week 14 out of a total of 21 planned weeks (Asmoro et al., 2024). Research using the Earned Value Analysis (EVA) method aims to identify factors causing delays and provide solutions that can be applied practically.

The EVA method allows the integration of schedule and cost to measure project performance. Based on previous research, the application of EVA to a sports construction project in Kedewan District (Riduwan et al., 2023) showed the effectiveness of this method in predicting project cost and time requirements. In addition, research by (Asmoro et al., 2023) underlines the importance of BCWP, BCWS, and ACWP in measuring time and cost efficiency in construction projects.

The Waru - Buduran Frontage Road project is faced with the problem of high implementation complexity. In addition to technical obstacles, there are social constraints, such as community protests regarding the project's impact on the surrounding environment (Setyawan et al., 2023). At the same time, the local government faced the challenge of maintaining a balance between accelerated development and control over project costs and quality (Balido et al., 2024).

The earned Value Method has been widely used in various projects to evaluate performance. For example, research by Ardiyanto and Kurniaw (2021) revealed that an SPI of less than one indicates significant delays in the construction of a showroom in Surabaya.

Project delays are often a source of dispute between project owners and contractors, as reported by (Balido et al., 2024) in the case of a road project in Pasuruan. This research emphasizes the need for effective communication between all parties to mitigate the risk of delays. Research by (Cahyono et al., 2023) on the BPBD building construction project in Pasuruan identified that the SPI of 0.949 indicates the need for more effective control strategies to avoid further delays. Good project management also requires a deep understanding of the external factors affecting project implementation. Previous research noted the importance of time and cost control to ensure efficiency in implementing construction projects at Jember State Polytechnic (Irniawan et al., 2023). In addition, research emphasized that delays in the trauma center project of the Madiun Regional Hospital can be overcome by utilizing EVA indicators to estimate duration and additional costs more accurately (Maulidi et al., 2021).

In the Waru - Buduran Frontage Road project, delays were caused by technical factors and coordination challenges between the various parties involved. This condition reflects the findings of (Setyawan et al., 2023) that lack of communication and careful planning can exacerbate time and cost deviations. For this reason, a holistic approach is needed that integrates quantitative analysis of project data through the EVA method. One important component of EVA is variance analysis, which includes Schedule Variance (SV) and Cost Variance (CV). This analysis provides an overview of project efficiency from a time and cost perspective. The research by (Maromi & Indryani, 2015) shows that projects with CPI values greater than one have good cost efficiency,

even though SPI shows delays. In addition, research by (Sudiarsa et al., 2023) on the Gianyar Regional Hospital project highlighted that the SPI value > 1 can be a positive indicator in measuring the success of project implementation time.

Based on the above background, this research aims to analyze the performance of the Waru - Buduran Frontage Road and Bridge construction project using the Earned Value Analysis (EVA) method. This analysis was conducted to identify the level of cost efficiency and project schedule and to reveal the main factors that caused project delays, both in technical, administrative, and social terms. In addition, this research also provides recommendations for more effective project control strategies to minimize the risk of delays and cost overruns. This research is expected to provide academic benefits in the development of construction project management literature, as well as practical benefits for project stakeholders in improving the effectiveness of infrastructure project management. In addition, this research also offers policy recommendations for related parties in more efficient project planning and strategies to mitigate the social impact of project delays.

RESEARCH METHOD

Approach

This research uses a quantitative descriptive approach to evaluate the cost and schedule performance of the Waru - Buduran Frontage Road and Bridge construction project. This approach aims to describe the measurement results in detail using Earned Value Analysis (EVA). Quantitative data is obtained from project financial reports and weekly work schedules, which are further analyzed to calculate EVA indicators. With this approach, the research can provide accurate information regarding the difference between the initial plan and the realization of the project. The results of the quantitative descriptive approach also enabled the identification of cost and schedule deviations, thus providing a basis for corrective action recommendations.

Location and Time of

The research was conducted on the Waru - Buduran Frontage Road and Bridge construction project in Sidoarjo Regency. The project's strategic location along the Surabaya-Sidoarjo corridor makes this project have a high level of complexity, especially in terms of coordination and implementation. The research occurred during the project implementation period, from week 1 to week 14. Data collected during this time included weekly progress, actual cost reports, cost estimates, and the project completion schedule.

Collection Technique

Research data was obtained through documentation and interview methods. Documentation includes project financial reports, implementation schedules, and planning documents used to calculate EVA indicators such as Planned Value (PV), Earned Value (EV), and Actual Cost (AC). Interviews were conducted with the project manager and implementation team

to understand the constraints faced during project implementation. This information helps complete the analysis and provides a broader context for the quantitative data obtained.

Analysis Technique

The data analysis technique used in this research is final value analysis (EVA). EVA measures project performance based on indicators such as Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI), and Cost Performance Index (CPI). The calculation is done by comparing the planned value, the costs incurred, and the value of the work completed. The results of this analysis are used to evaluate the project's overall efficiency.

Validation and Verification

Data validation is carried out by comparing project progress data obtained from documentation with direct observation in the field. This aims to ensure that the data used in the EVA analysis is based on the actual conditions in the field. Data was verified through discussions with relevant parties, including project managers and supervisory consultants. This process ensures that the interpretation of the data is appropriate to the context of project implementation and provides reliable results for evaluating cost and schedule performance.

RESULT AND DISCUSSION

Schedule Variance Analysis

Schedule Variance (SV) is an important metric in project management using the Earned Value Management (EVM) framework that measures the difference between the value of work planned to be completed and the value of work completed at a given time (Ramadhani et al., 2024), with the formula SV = BCWP - BCWS. In the Waru - Buduran Frontage Road project, the analysis at week 14 showed a significant negative deviation of -9.911%, which means a delay compared to the planned progress of 45.263%, with a realized progress of only 35.352%. The leading causes of this delay include technical challenges such as utility relocation and land acquisition, coordination gaps between stakeholders, and external factors such as bad weather. The implications of this deviation include increased overhead costs, resource conflicts, and decreased stakeholder confidence. Overcoming this requires improving schedule planning using tools like Primavera, strengthening coordination through regular meetings, and utilizing predictive analytics to anticipate delay risks. This approach must be supported by integrated performance analysis such as Schedule Performance Index (SPI) and prediction through Estimate to Complete (ETC) so that corrective actions can be taken promptly. Similar case studies show that proactive SV control can prevent negative project cost and schedule impacts. Therefore, accurate SV analysis and appropriate mitigation actions are key to the success of large construction projects such as this.

Table 1. Recapitulation of SV Calculation

MINGGU	BCWP	BCWS	SV
a	b	c	d=b-c
1	110.988.550	31.380.691	79.607.859
2	115.613.073	62.770.209	52.851.691
3	119.576.950	118.258.888	1.321.292
4	135.432.457	173.947.367	-38.647.799
5	6.676.820.126	181.447.476	6.495.472.763
6	6.680.453.680	188.947.586	6.491.508.887
7	6.683.096.265	628.530.287	6.054.491.471
8	8.275.914.087	1.360.372.156	6.915.643.703
9	8.322.489.640	2.662.449.015	5.660.085.730
10	8.376.332.299	4.021.011.871	4.355.309.621
11	8.443.718.205	5.963.484.346	2.480.395.900
12	8.736.384.441	7.615.099.674	1.121.446.808
13	9.286.042.022	10.794.919.498	-1.508.915.764
14	11.677.581.018	14.280.542.982	-2.602.945.758

Source: Processed by Researcher

Cost Variance (CV Analysis

This project's cost variance (CV) shows cost efficiency despite schedule delays. At week 14, the CV recorded a positive value of 3.8%, which means the costs incurred were lower than the planned budget. This efficiency was mainly due to the optimization of resource use during implementation. Nonetheless, this cost efficiency does not fully compensate for the impact of schedule delays. Based on interviews with the project manager, a more timely material procurement strategy contributed to cost efficiency. This information forms the basis for maintaining cost efficiency without compromising the project schedule. The CV results indicate that project management successfully manages expenditures. However, there is a need for improved schedule coordination to optimize overall project performance.

Table 2. Recapitulation of CV Calculation

MINGGU	BCWP	ACWP	CV
a	b	c	d=b-c
1	110.988.550	106.944.780	4.043.770
2	115.613.073	111.400.813	4.212.260
3	119.576.950	115.220.269	4.356.681
4	135.432.457	130.498.095	4.934.362
5	6.676.820.126	6.433.556.080	243.264.047
6	6.680.453.680	6.437.057.248	243.396.432
7	6.683.096.265	6.439.603.552	243.492.713
8	8.275.914.087	7.974.388.464	301.525.624
9	8.322.489.640	8.019.267.077	303.222.563
10	8.376.332.299	8.071.148.027	305.184.273

MINGGU	BCWP	ACWP	CV
a	b	c	d=b-c
11	8.443.718.205	8.136.078.786	307.639.419
12	8.736.384.441	8.418.081.986	318.302.455
13	9.286.042.022	8.947.713.279	338.328.743
14	11.677.581.018	11.252.118.662	425.462.355

Source: Processed by Researcher

Discussion

Schedule Variance (SV) Analysis

Schedule Variance (SV) and Cost Variance (CV) on the Waru - Buduran Frontage Road and Bridge construction project provide an in-depth description of the cost and schedule performance of the project in answering the first problem formulation, namely how the cost and schedule performance using final value analysis on the project.

Schedule Variance (SV), which shows a negative deviation of -9.911% in week 14, is a key indicator that the project is experiencing significant delays compared to the plan. This negative SV value indicates that the physical progress achieved is less than what should have been according to the planned schedule. In other words, a mismatch between the target time and actual results demands special attention to make strategic schedule improvements. Constraints such as delays in utility removal, community protests, and the influence of bad weather were the dominant factors that worsened the project schedule performance.

Based on the Earned Value Analysis (EVA) results on the Waru - Buduran Frontage Road and Bridge construction project, schedule performance shows a significant negative deviation. The Schedule Variance (SV) value of -9.911% at week 14 reflects that the progress is lower than planned in the project schedule. This deviation is a key indicator that the project is experiencing delays that must be addressed immediately to avoid escalating the problem to the next phase. Previous research has also highlighted that less effective coordination with third parties, such as utility owners and local governments, can prolong the duration of fieldwork (Abrinaldi & Nurcahyo, 2022). Therefore, a more integrated risk management approach is needed to anticipate these obstacles in future projects.

Factors Influencing Schedule Delay

Various factors, both internal and external, influenced this delay. Internally, technical constraints such as removing utilities, including telecommunication and electricity poles, have been a challenge that has not been completed on schedule. This process requires coordination with third parties, often failing to go smoothly. External factors, such as heavy rainfall that hampered activities on the ground, further exacerbated the situation. This erratic weather caused work such as excavation, casting, and other site works to be delayed, resulting in missed schedule targets.

In addition, the Schedule Performance Index (SPI) of 0.89 indicates that the project is running slower than planned. This value indicates that for every 1 unit of work planned, only 0.89

units are completed within the same time. This discrepancy indicates the need to re-plan and optimize the implementation of activities on the project's critical path to catch up with the delays that occurred. Other causes include land acquisition issues and protests from the community regarding the project's impact on the surrounding environment. These constraints affect the work schedule and can increase the risk of cost escalation if not addressed immediately. This is in line with previous research which states that infrastructure projects often face similar challenges, such as delays in land acquisition and disagreements with local communities, which contribute to schedule delays and increased project costs (Sari et al., 2024).

Implications of Negative Schedule Variance

The implications of this negative SV extend to several aspects of the project. First, delays can lead to delays in completing subsequent phases, potentially impacting the overall project schedule. Second, non-compliance with the planned schedule can affect stakeholder confidence, including contractors, clients, and the local community. Third, schedule deviations often result in increased work pressure on the workforce and other resources, ultimately affecting the deliverables' quality.

Overall, the SV analysis results show the importance of implementing more effective schedule management strategies to improve schedule performance. Integrated corrective measures are needed to ensure that project completion can return to plan while minimizing the negative impact of delays that have occurred.

Cost Variance (CV) Analysis

From a cost perspective, the project showed significant efficiency with a positive Cost Variance (CV) value of 3.8%. This reflects that the cost incurred to complete the work was lower than the planned budget. This efficiency results from implementing effective cost management strategies, including better-planned material procurement and competitive price negotiations.

The optimization of human resources and equipment supports this success in cost management. More efficient work scheduling enabled a reduction in labor costs without compromising productivity (Ariyandi, 2025). In addition, the well-planned use of heavy equipment helped reduce operational costs while ensuring that work could be completed according to technical specifications. This success demonstrates that the project team was able to manage costs efficiently despite facing significant challenges in the schedule aspect.

Imbalance Between Cost and Schedule Performance

However, the imbalance between positive CV and negative SV results indicates a gap in cost and schedule management integration. Although cost efficiency is achieved, schedule delay is still a significant challenge that needs to be addressed. When the project schedule is delayed, there is a risk that the cost savings achieved in the early stage may be eroded by additional costs that arise in the late stage, such as acceleration costs or penalties due to delay.

The Cost Performance Index (CPI) 1.04 confirms that every Rp 1 spent produced Rp 1.04 worth of work. This value indicates that the project is well managed in terms of expenditure.

However, to maintain the consistency of cost performance, it is necessary to strive so that the project schedule is no longer delayed and that additional costs can be avoided. The efficiency achieved through positive CV can also be utilized to support acceleration measures, such as additional workforce or more advanced technology to pursue schedule targets.

By utilizing CV analysis, project managers can identify areas that require more attention in cost management. In addition, the cost efficiencies achieved form the basis for allocating resources more strategically, including funding initiatives to improve schedule performance. In conclusion, positive CV results indicate successful cost management, but efforts to align cost and schedule performance remain a priority that must be considered in the next stage of the project.

Strategic Integration of SV and CV Analysis

The Cost Variance (CV) analysis showed a positive efficiency of 3.8%, meaning that actual costs were lower than the planned budget. This efficiency reflects success in cost management strategies, such as more organized material procurement, competitive price negotiations, and optimization of human resources and heavy equipment. However, despite the cost efficiency achieved, the negative impact of schedule delays remains a challenge that project management must overcome. The apparent imbalance between negative SV and positive CV reflects a gap in the synergy between cost and schedule performance, where cost efficiency has not fully compensated for the impact of time delays.

Positive cost performance, indicated by CV values and schedule performance challenges measured through SV, explains how these indicators can be used to evaluate and improve overall project performance. Where negative SV indicates the need for schedule acceleration or restructuring, positive CV provides an opportunity to leverage cost efficiencies to support such measures without adding financial pressure to the project. The project can get back on track by integrating these findings into project management strategies, such as schedule adjustments, resource reallocation, and more intensive communication between stakeholders. These results also underscore the importance of SV and CV analysis in providing a solid basis for better decision-making regarding managing project time and cost by the main objective of the final value evaluation.

CONCLUSION

The conclusion of this research shows the results of variance analysis using the Earned Value Method (EVM) in the Waru - Buduran Frontage Road and Bridge construction project. This research found a significant schedule deviation, with a Schedule Variance (SV) of -9.911% in week 14, which indicates a significant delay in the project. This delay was mainly due to internal factors such as technical obstacles in utility relocation and external factors including bad weather conditions. The Schedule Performance Index (SPI) of 0.89 further confirms that the project is running slower than planned. In contrast, cost performance shows efficiency, with a positive Cost Variance (CV) of 3.8%, reflecting that actual costs are lower than planned budget. This efficiency

was achieved through strategic cost management, including better planned material procurement and competitive price negotiations. However, the misalignment between cost efficiency and schedule delays highlights the need for an integrated project management strategy to prevent cost savings being eliminated by prolonged schedules. To address this, corrective actions should focus on improving schedule performance through improved coordination, proactive risk mitigation, and optimal resource allocation.

This research contributes to the field of construction project management by demonstrating the practical application of EVM in assessing and improving project efficiency. These findings emphasize the importance of aligning cost and schedule management to improve overall project performance. Future research can build on this research by exploring advanced predictive analytics and machine learning applications to improve the accuracy of project forecasts. In addition, integrating digital project management tools such as Building Information Modeling (BIM) with EVM can be explored to further optimize schedule and cost performance in large-scale infrastructure projects. By implementing these improvements, future projects can minimize delays and cost overruns, ensuring more effective and sustainable infrastructure development.

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