

Analysis of The Effectiveness of Earned Value Method In Road Widening Project Management In Mojokerto Regency

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KEYWORDS

cost; time; earned value

ABSTRACT

In construction project management, achieving three main goals, namely cost, quality, and time, becomes the primary focus. This study aims to evaluate a road widening project in Mojokerto Regency with a target completion time of 150 days. To prevent delays and cost overruns, researchers adopted the Earned Value method as a tool to identify early warnings regarding project performance. This method integrates cost and time measurements through indicators such as Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), Estimated at Completion (EAC), and Estimated Schedule at Completion (EAC). The analysis results show that the additional costs required (ETC) amounted to Rp 3,276,704,110.14, with an estimated additional time (ETS) up to the 12th week being 87 days. The project's cost change (EAC) reached Rp 3,961,767,811.01 from the contract cost, while the estimated project completion time (EAS) was 171 days. These findings indicate that the construction service provider has implemented an efficient execution method with consistent monitoring, ensuring the smooth progress of the project.

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Introduction

The development of infrastructure in Indonesia, especially roads, has become the government's focus in efforts to meet the increasing connectivity needs in various regions, both urban and rural (Alkas et al., 2023). In response to this need, the government has launched a series of road construction projects. However, as the number and complexity of highway projects grows, their management and implementation become more complicated. According to Law no. 38 of 2014 and Government Regulation no. 34 of 2006, roads are considered an important part of land transportation facilities which include all facilities and equipment used for traffic (Araszkievicz & Bochenek, 2019). In this context, project management becomes a key element in ensuring that highway projects can be completed on time, within the established budget, and with adequate quality. (Iman Soeharto. Ir, 1999) stated that project management includes all stages, from

planning to implementation, with the aim of achieving appropriate control so that the project is completed according to the predetermined schedule (Asmoro et al., 2023). However, various challenges such as unexpected weather disruptions and delays in material delivery often hinder project implementation, which in turn can result in increased costs and delays in project completion (Bonny et al., 2022).

During limited resources, both funds and time, careful planning before project implementation becomes very important. Good planning must take into account various aspects, including the quality of work and project implementation control, to ensure the success of the project according to plan (Christy et al., 2023). However, there is often a gap between initial plans and project realization, which can cause delays and increased costs. Therefore, controlling project performance becomes very important. The Earned Value Analysis (EVA) method is a tool that can be used to monitor and control project performance holistically (Witjaksana & Reresi, 2012). EVA allows the calculation of the project's physical completion, planned costs, and actual costs incurred, providing a clear picture of the project's performance in a given period. Thus, EVA helps in predicting the total cost and time required to complete the project (Indramanik et al., 2022). In the context of the road widening project towards the standard Bendung Bantengan road section, the use of the Earned Value Method is very important to ensure that the project remains according to plan, avoid delays, and prevent costs from increasing (Mahapatni et al., 2022). By taking into account various factors that may influence project implementation, such as weather changes and efficient resource management, EVA provides information that is important for controlling project performance (Nandaprasetya & Dofir, 2021).

Thus, careful planning, effective project performance control, and the use of tools such as the Earned Value Method are critical to achieving road construction project success (Pratama, 2022). By understanding and overcoming challenges that may arise during project implementation, the government and developers can ensure that the road infrastructure built can meet community needs efficiently and in accordance with established standards.

Research Methods

This research focuses on the road widening project towards the standard Bendung Bantengan road section in Mojokerto Regency, with emphasis on the role of the Director or Project Manager. The research location is at coordinates 7.3842°S and 112.4457°E. Data for this research was collected through field observations, interviews, and analysis of project documents such as implementation schedules (time schedules), S curves (master schedules), weekly progress reports, and actual cost records. This approach provides a comprehensive view of project development as well as challenges that arise during implementation. Data collection was carried out using direct observation and interviews to obtain primary data, while project documents provided secondary data. Data analysis uses techniques such as calculating work weights (Workload Factor, WF), cost variance (Cost Variance, CV), schedule variance (SV), cost performance index (CPI), and schedule performance index (Schedule Performance Index, SPI). These techniques help measure a project's cost efficiency and time performance, allowing early identification of potential delays or cost overruns.

The results of data analysis provide important insights into project management, enabling estimates of completion time and costs to project completion. The Earned Value Analysis (EVA) method is used to calculate Estimate Time To Complete (ETC) and

Estimate At Completion (EAC), which provides a clear picture of the time and costs still required. These findings serve as an early warning tool for project management, allowing them to take necessary corrective actions to ensure that the project can be completed on time and on budget.

Results and Discussions

Project Overview

The project that is the object of research is the Road Widening Project to Standardize the Bendung Bantengan Road Section. The location of this project is in the Mojokerto Regency area. Mojokerto Regency is one of the districts in East Java Province. From year to year, land use in the Mojokerto Regency area has experienced a change in function, for example agricultural land has changed its function to residential land, yards, buildings, and industrial land and some has been converted into roads (Sakinah, 2021). To support the development of industrial areas in Mojokerto Regency, it needs to be supported by supporting facilities, the main of which is the development of road and bridge infrastructure. The realization of development, especially road infrastructure, by the Mojokerto Regency Government through the Department of Public Works and Spatial Planning (DPUPR), is now accelerating due to the implementation of the construction e-catalog in 2024. The aim of accelerating road construction is to improve infrastructure so that the impact can be felt directly by the community and can boost the economy in the area (Sujarwo & Oetomo, 2022).

Project Organizational Structure

This project organizational structure is a functional organizational structure, which is formed based on the types of activities or functions, each of which is intended to support the project. Each function or activity is organized according to its respective area of expertise, so that it appears as if it stands alone. However, even though they appear separate, each function or activity in this organization is actually interdependent on each other and cannot operate independently (Tanjung, 2017).

Cost component

Budget Cost of Work Schedule (BCWS)

Budgeted Cost of Work Scheduled (BCWS) is the planned budget value for project work that is scheduled to be completed within a certain period. As part of the Earned Value Management (EVM) methodology, BCWS helps project managers compare budgeted costs with actual costs incurred and work completed, making it easier to monitor cost performance and project control. With BCWS, project managers can identify budget deviations and take corrective action to keep projects on schedule and on budget (Widiasanti & Lenggogeni, 2013).

Table 1 Recapitulation of BCWS/PV Analysis Results

Week	Project Budget Value	Cumulative Plan Weight	BCWS (RP)
1	Rp 4,037,886,000.00	0.008	Rp 323,030.88
2	Rp 4,037,886,000.00	0.031	Rp 1,251,744.66
3	Rp 4,037,886,000.00	0.054	Rp 2,180,458.44
4	Rp 4,037,886,000.00	0.271	Rp 10,942,671.06
5	Rp 4,037,886,000.00	1.571	Rp 63,435,189.06
6	Rp 4,037,886,000.00	4.210	Rp 169,995,000.06
7	Rp 4,037,886,000.00	7.657	Rp 309,180,931.02
8	Rp 4,037,886,000.00	7.664	Rp 309,443,393.61
9	Rp 4,037,886,000.00	7.670	Rp 309,685,666.77
10	Rp 4,037,886,000.00	11.539	Rp 465,911,476.11

11	Rp 4,037,886,000.00	16.169	Rp 652,865,597.91
12	Rp 4,037,886,000.00	24.725	Rp 998,347,124.07

Source: Researcher's Process, 2024

From the data in Table 1, it can be concluded that the project shows positive progress week by week, with gradual increases in the cumulative weight of work plans and BCWS scores. Although the project budget remained stable, the planned budget for work to be done (BCWS) increased significantly as the project progressed. This shows that project planning is proceeding according to plan, and the budget allocation for each job follows the established plan. However, careful supervision continues to be needed to ensure that work is carried out in accordance with the planned budget, so that the project can run efficiently and in accordance with the set targets.

Budget Cost of Work Performance (BCWP)

Budgeted Cost of Work Performance (BCWP) is a measure of the actual value of work completed in a project, assessed based on the budget value that has been planned for that work. BCWP allows project managers to compare actual cost performance with established budget plans, thereby enabling accurate evaluation of project performance in terms of cost expenditure. By comparing BCWP with Budgeted Cost of Work Scheduled (BCWS) and Actual Cost of Work Performed (ACWP), project managers can measure project performance holistically and identify deviations from the budget plan and take necessary corrective steps.

Table 2 Recapitulation of BCWP/EV Analysis Results

Week	Project Budget Value	Cumulative Plan Weight	BCWP (RP)
1	Rp 4,037,886,000.00	0.000	Rp. -
2	Rp 4,037,886,000.00	0.007	Rp 282,652.02
3	Rp 4,037,886,000.00	0.013	Rp 524,925.18
4	Rp 4,037,886,000.00	0.129	Rp 5,208,872.94
5	Rp 4,037,886,000.00	1.952	Rp 78,819,534.72
6	Rp 4,037,886,000.00	4.069	Rp 164,301,581.34
7	Rp 4,037,886,000.00	6.134	Rp 247,683,927.24
8	Rp 4,037,886,000.00	6.141	Rp 247,966,579.26
9	Rp 4,037,886,000.00	6.318	Rp 255,113,637.48
10	Rp 4,037,886,000.00	7.058	Rp 284,993,993.88
11	Rp 4,037,886,000.00	10.145	Rp 409,643,534.70
12	Rp 4,037,886,000.00	18.851	Rp 761,181,889.86

Source: Researcher's Process, 2024

Table 2 depicts the BCWP/EV analysis results for each week in the project. In this analysis, BCWP (Budgeted Cost of Work Performed) reflects the value of work that has been successfully completed. The BCWP value has increased significantly from week to week, indicating consistent project progress. Even though the BCWP in the first week was not recorded because no work had been completed, from the second week to the 12th week, the BCWP continued to increase along with the completion of the work. This indicates that the project is progressing according to plan, with budget allocation for the work completed in accordance with the overall progress of the project.

ACWP (Actual Cost of Work Performed)

Actual Cost of Work Performed (ACWP) is the total actual costs that have been incurred for work that has been completed on a project in a certain time. ACWP helps project managers compare actual costs with planned budgets, thereby enabling evaluation of overall project cost performance and making appropriate decisions in controlling expenditure.

Table 3 Recapitulation of ACWP results

Week	Project Budget Value	Cumulative Plan Weight	ACWP (RP)
1	Rp 3,634,097,400.00	0.000	Rp. -
2	Rp 3,634,097,400.00	0.007	Rp 254,386.82
3	Rp 3,634,097,400.00	0.013	Rp 472,432.66
4	Rp 3,634,097,400.00	0.129	Rp 4,687,985.65
5	Rp 3,634,097,400.00	1.952	Rp 70,937,581.25
6	Rp 3,634,097,400.00	4.069	Rp 147,871,423.21
7	Rp 3,634,097,400.00	6.134	Rp 222,915,534.52
8	Rp 3,634,097,400.00	6.141	Rp 223,169,921.33
9	Rp 3,634,097,400.00	6.318	Rp 229,602,273.73
10	Rp 3,634,097,400.00	7.058	Rp256,494,594.49
11	Rp 3,634,097,400.00	10.145	Rp 368,679,181,23
12	Rp 3,634,097,400.00	18.851	Rp 685,063,700.87

Source: Researcher's Process, 2024

Table 3 presents a summary of the ACWP (Actual Cost of Work Performed) analysis results for each week in the project, which reflects the actual costs incurred for the work that has been completed. The ACWP value also increases from week to week, indicating an increase in the costs used to complete the work. Even though the ACWP in the first week was not recorded because no work had been completed, from the second week to the 12th week, the ACWP continued to increase along with the completion of the work. This indicates that the costs incurred for completed work continue to increase as the overall project progresses.

Variance Calculation

Schedule Varians (SV)

Schedule Variance (SV) is a measure of the difference between the planned value of work and the value of work that has been completed at a point in time in the project. A positive SV indicates that the work has been completed more quickly than planned, while a negative SV indicates a delay in completing the work. By monitoring SV, project managers can identify whether the project is on schedule or experiencing delays, so they can take the necessary corrective steps.

Table 4 Calculation of Time Variance Value (SV)

Week	BCWP (Rp)	BCWS (Rp)	SV	Information
1	Rp. -	Rp 323,030.88	-Rp 323,030.88	Late
2	Rp 282,652.02	Rp 1,251,744.66	-Rp 969,092.64	Late
3	Rp 524,925.18	Rp 2,180,458.44	-Rp 1,655,533.26	Late
4	Rp 5,208,872.94	Rp 10,942,671.06	-Rp 5,733,789.12	Late
5	Rp 78,819,534.72	Rp 63,435,189.06	Rp 15,384,345.66	Fast
6	Rp 164,301,581.34	Rp 169,995,000.06	-Rp 5,693,419.26	Late
7	Rp 247,683,927.24	Rp 309,180,931.02	-Rp 61,497,003.78	Late
8	Rp 247,966,579.26	Rp 309,443,393.61	-Rp 61,476,814.35	Late
9	Rp 255,113,637.48	Rp 309,685,666.77	-Rp 54,572,029.29	Late
10	Rp 284,993,993.88	Rp 465,911,476.11	-Rp 180,917,482.23	Late
11	Rp 409,643,534.70	Rp 652,865,597.91	-Rp 243,222,063.21	Late
12	Rp 761,181,889.86	Rp 998,347,124.07	-Rp 237,165,234.21	Late

Source: Researcher's Process, 2024

Table 4 presents the calculation of Time Variance (SV) in the project, which measures the difference between the BCWP (Budgeted Cost of Work Performed) and BCWS (Budgeted Cost of Work Schedule) values. SV is calculated by subtracting the

BCWS value from BCWP. Negative results indicate delays in completing work from the planned schedule, while positive results indicate completion ahead of schedule. For example, in the first week, with a BCWP of Rp. 0 and a BCWS of Rp. 323,030.88, the SV in the first week was -Rp. 323,030.88, indicating a delay in work implementation. Table analysis shows that most of the project weeks experienced delays in completing work from the planned schedule, except in the fifth week, where completion of work was carried out ahead of schedule.

Cost Varians (CV)

Cost Variance (CV) is a measure of the difference between the value of work that has been completed (BCWP) and the actual costs that have been incurred (ACWP) in a project. CV is used to assess project cost efficiency by comparing the planned costs with the actual costs incurred for the work completed to that point. If the CV is positive, it means that the costs incurred are lower than planned, indicating cost savings. On the other hand, if the CV is negative, it means that the costs that have been incurred exceed those planned, indicating expenditures more than the predetermined budget. By monitoring CV, project managers can evaluate the overall project cost performance and take necessary corrective actions to keep the project within the established budget.

Table 5 Calculation of Cost Variance Value (CV)

Week	BCWP (Rp)	BCWS (Rp)	CV
1	Rp. -	Rp. -	Rp. -
2	Rp 282,652.02	Rp 254,386.82	Rp 28,265.20
3	Rp 524,925.18	Rp 472,432.66	Rp 52,492.52
4	Rp 5,208,872.94	Rp 4,687,985.65	Rp 520,887.29
5	Rp 78,819,534.72	Rp 70,937,581.25	Rp 7,881,953.47
6	Rp 164,301,581.34	Rp 147,871,423.21	Rp 16,430,158.23
7	Rp 247,683,927.24	Rp 222,915,534.52	Rp 24,768,392.72
8	Rp 247,966,579.26	Rp 223,169,921.33	Rp 24,796,657.93
9	Rp 255,113,637.48	Rp 229,602,273.73	Rp 25,511,363.75
10	Rp 284,993,993.88	Rp 256,494,594.49	Rp 28,499,399.39
11	Rp 409,643,534.70	Rp 368,679,181.23	Rp 40,964,353.47
12	Rp 761,181,889.86	Rp 685,063,700.87	Rp 76,118,188.99

Source: Researcher's Process, 2024

Table 5 illustrates the calculation of Cost Variance (CV) in a project, which measures the difference between the BCWP (Budgeted Cost of Work Performed) and ACWP (Actual Cost of Work Performed) values. CV is calculated by subtracting the ACWP value from BCWP. If the result is positive, it indicates that the work was carried out at a lower cost than planned. For example, in the second week, with a BCWP of IDR 282,652.02 and an ACWP of IDR 254,386.82, the CV was IDR 28,265.20, indicating a cost savings of IDR 28,265.20. Table analysis shows that most weeks of the project were carried out at lower costs than planned, except in week 11, where the costs incurred exceeded those planned by IDR 40,964,353.47.

Performance Index Calculation

Schedule Performance Index (SPI)

The Schedule Performance Index (SPI) is a measure of the efficiency of completing a project schedule, compared to the planned schedule. An SPI of more than 1 indicates the project is progressing faster than planned, below 1 indicates a delay, and 1 indicates completion as planned. By monitoring SPI, managers can evaluate project schedule performance and take necessary corrective actions.

Table 6 Calculate SPI

Week	BCWP (Rp)	BCWS (Rp)	SPI
1	Rp. -	Rp. -	0.00
2	Rp 282,652.02	Rp 254,386.82	0.23
3	Rp 524,925.18	Rp 472,432.66	0.24
4	Rp 5,208,872.94	Rp 4,687,985.65	0.48
5	Rp 78,819,534.72	Rp 70,937,581.25	1.24
6	Rp 164,301,581.34	Rp 147,871,423.21	0.97
7	Rp 247,683,927.24	Rp 222,915,534.52	0.80
8	Rp 247,966,579.26	Rp 223,169,921.33	0.80
9	Rp 255,113,637.48	Rp 229,602,273.73	0.82
10	Rp 284,993,993.88	Rp256,494,594.49	0.61
11	Rp 409,643,534.70	Rp 368,679,181,23	0.63
12	Rp 761,181,889.86	Rp 685,063,700.87	0.76
Mean SPI			0.63

Source: Researcher's Process, 2024

Table 6 presents the Schedule Performance Index (SPI) calculation for the project for 12 weeks. SPI is calculated as the ratio between BCWP (Budgeted Cost of Work Performed) and BCWS (Budgeted Cost of Work Scheduled), namely $SPI = BCWP / BCWS$. In the first week, the SPI is 0.00 because no work has been completed. The second and third weeks showed delays with SPIs of 0.23 and 0.24 respectively. In the fourth week, the SPI increased to 0.48, but the project was still under schedule. Improvement occurred in the fifth week with an SPI of 1.24, indicating the project was running ahead of schedule. However, from the sixth week to the twelfth week, the SPI varied between 0.61 and 0.97, indicating the project was again running under the planned schedule. The 12-week SPI average was 0.63, indicating the project was progressing slower than the planned schedule. SPI values consistently below 1 indicate the need for evaluation and improvement in project time management.

Cost Performance Index (CPI)

The Cost Performance Index (CPI) is used to evaluate the cost efficiency of a project, showing how well the project budget is utilized. CPI is calculated by dividing BCWP (Budgeted Cost of Work Performed) by ACWP (Actual Cost of Work Performed), with the formula $CPI = BCWP / ACWP$. Even though in the first week there was no data available to calculate the CPI, the value was 0.00, from the second week to the twelfth week, the CPI value was consistently at 1.11. This indicates that the planned costs and actual costs of the project were at the same level during the period, indicating efficient use of the budget.

Table 7 CPI calculation

Week	BCWP (Rp)	BCWS (Rp)	CPI
1	Rp. -	Rp. -	0.00
2	Rp 282,652.02	Rp 254,386.82	1.11
3	Rp 524,925.18	Rp 472,432.66	1.11
4	Rp 5,208,872.94	Rp 4,687,985.65	1.11
5	Rp 78,819,534.72	Rp 70,937,581.25	1.11
6	Rp 164,301,581.34	Rp 147,871,423.21	1.11
7	Rp 247,683,927.24	Rp 222,915,534.52	1.11
8	Rp 247,966,579.26	Rp 223,169,921.33	1.11
9	Rp 255,113,637.48	Rp 229,602,273.73	1.11
10	Rp 284,993,993.88	Rp256,494,594.49	1.11

11	Rp 409,643,534.70	Rp 368,679,181,23	1.11
12	Rp 761,181,889.86	Rp 685,063,700.87	1.11

Source: Researcher's Process, 2024

Table 7 provides an overview of the Cost Performance Index (CPI) over the duration of the project. CPI is an important indicator that measures the efficiency of budget use in a project, calculated by dividing BCWP (Budgeted Cost of Work Performed) by ACWP (Actual Cost of Work Performed). From the second week to the fourteenth week, the CPI value was stable at 1.11, indicating consistency in budget use. For example, in the second week, the CPI was 1.11, with BCWP IDR 282,652.02 and ACWP IDR 254,386.82. This pattern continued until the fourteenth week, indicating that each budget invested resulted in more work value than was budgeted. This reflects efficient cost management, which can result in significant cost savings.

Calculation of Project Time and Cost Estimates

Creating cost estimates or project completion schedules based on indicators obtained during reporting is an important step to anticipate changes and manage projects more effectively. By using indicators such as the Cost Performance Index (CPI) and Schedule Performance Index (SPI), we can estimate the cost at the end of the project (Estimate at Completion = EAC) and the estimated time for project completion (Estimate all Schedule = EAS). EAC can be estimated by dividing the total planned cost (Budgeted Cost of Work Scheduled = BCWS) by CPI, while EAS can be calculated by dividing the total planned project duration by SPI. Thus, these estimates provide a more realistic view of the project's progress and results, helping project managers to take appropriate steps to ensure the project remains on track.

Calculation of Final Estimated Project Time

Cost or schedule estimates play an important role in project management because they provide insight into possible changes that will occur in the future, based on trends seen at the time of reporting. At the 12th week review stage, the estimated remaining work time, referred to as the Estimate Temporary Schedule (ETS), can be calculated using the following formula: $ETS = (\text{remaining time}) / SPI$. In this case, with 66 days remaining and an SPI of 0.76, the ETS is 87 days. Next, the estimated completion time for all work, called Estimate All Schedule (EAS), can be calculated by adding ETS to the current completion time. Thus, the EAS is 171 days. From this calculation, it can be concluded that the project construction time is estimated to last 171 days, exceeding the previously planned schedule of 21 days. This highlights the importance of proper monitoring and organization in project management to manage changes that may occur during project implementation.

Calculation of Estimated Final Project Costs

At the final review stage, precisely in week 12, the estimated remaining costs required to complete the project, known as Estimate Temporary Cost (ETC), can be calculated using the formula: $ETC = \text{Budget} - BCWP$. In this context, with an initial budget of IDR 4,037,886,000 and a BCWP at that time of IDR 761,181,889.86, the ETC was IDR 3,276,704,110.14. Next, to get an estimate of the final cost of the project, referred to as Estimate at Completion (EAC), it can be calculated by adding ETC to the actual cost at that time, ACWP. Thus, the EAC is IDR 3,961,767,811.01. From these calculations, it can be concluded that the final project cost value is estimated to be lower than the initial contract cost. This indicates possible cost savings or efficiencies in project implementation, which can be considered a positive outcome in project management.

Conclusion

Based on the results of the analysis of the Widening Towards Standards Bendung Bantengan Road Section project in Mojokerto Regency, several conclusions can be drawn. First, the estimated remaining costs needed to complete the project, known as Estimated Temporary Cost (ETC), is IDR 3,276,704,110.14. The change in the total cost to complete the project, called Estimate All Cost (EAC), showed a decrease of 0.811% from the initial contract cost, indicating efficiency in cost management. Second, the estimated remaining time required to complete the project, known as the Estimate Temporary Schedule (ETS), at the end of the 12th week review was 87 days. However, to complete the entire project, the estimated time, called Estimate All Schedule (EAS), is 171 days. Therefore, the project implementation time is expected to exceed the previous plan by 21 days. This conclusion highlights the importance of proper monitoring and management in project management to manage changes that may occur during project implementation.

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