COST AND TIME ANALYSIS USING THE EARNED VALUE ANALYSIS METHOD

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ABSTRACT

Construction project management prioritizes the achievement of three main objectives: cost, quality, and time. This study evaluates a road widening project in Mojokerto Regency with a target completion time of 150 days. To prevent delays and cost overruns, researchers used the Earned Value method to identify early warnings regarding project performance. This method integrates time and cost values through measurements of 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 research findings show that additional costs required (ETC) reached Rp 3,276,704,110.14, with additional time (ETS) up to week 12 being 87 days. The change in project costs (EAC) reached Rp 3,961,767,811.01 from the contract cost, while the project completion time (EAS) was 171 days. The analysis indicates that the construction service provider has implemented an efficient implementation method with consistent supervision, ensuring the smooth progress of the project.

KEYWORDS	*Cost, Time, Earned Value*

INTRODUCTION

Along with the rapid development of infrastructure in Indonesia, roads have become one of the vital infrastructures for urban, rural, and industrial areas. The government is responding with various construction projects to meet the increasing needs of the community (Aman et al., 2021). The increase in road projects adds complexity to the management and implementation, resulting in longer project duration. According to Law No.38 of 2014 and Government Regulation No.34 of 2006, roads are land transportation facilities that include all facilities, including equipment used for traffic. A project is defined as an activity with a specific timeframe and limited resource allocation to carry out a specific task. Project management is applied at all stages-planning, design, procurement, and execution-so its application is complex and intricate (Araszkiewicz & Bochenek, 2019). The

goal is to achieve proper control so that the project is completed within the set schedule, budget, and quality. Construction projects involve resources such as materials, people, costs, time, and tools, which require good management to control the project. The success of a construction project is highly dependent on good cost, quality, and time control, therefore attention to the quality and accuracy of project completion is very important (Arifin et al., 2023; Nurtsani et al., 2017).

Scheduling planning with limited resources must be carefully analyzed. One way to overcome scheduling with limited resources is to systematically determine standards that are in accordance with planning objectives and take into account possible deviations between implementation and project standards (Pratama, 2022). Project performance indicators in terms of time and cost enable preventive measures to keep the project on track. A concrete example is the road widening project to the standard of the Bendung Bantengan road section implemented by CV. Lutfi Bangun Persada. This project has a duration of 150 calendar days with a contract value of Rp. 4,037,866,000.00. The purpose of widening this road was to facilitate the economic and social relations of the community, and almost all routes between sub-districts in the Mojokerto area have used concrete roads. However, the project faced challenges, such as rain during the day that hampered work, resulting in less effective working time than planned (Bonny et al., 2022). In addition, delivery of materials to the site was often delayed due to damaged roads.

With limited funds and time available, good planning is required before the project is implemented. Great attention is required to the quality of work and control of project implementation to ensure the project can be completed as planned. Often, problems are encountered in the field that cause the time, quality, and cost of the project to not be in accordance with the initial plan, often causing overbudget (Indramanik et al., 2022). Therefore, control needs to be carried out to overcome the deviations that occur. During project implementation, planning and controlling cost and time is an integral part of construction project management. Project assessment is not only in terms of quality, but also in terms of cost and time (Christy et al., 2023). The costs that have been incurred and the time taken to complete the work must be continuously measured for deviations from the plan. Significant deviations in cost and time indicate poor project management. Planning is the key to achieving resource efficiency and effectiveness during the execution of activities. Without good planning, the project will not run smoothly as expected. Projects have limited costs, time, and resources, so good planning is needed to overcome these limitations. Based on the planning that has been made, it can be a reference to achieve the expected goals (Ervianto, 2023).

There is often a mismatch between the planning time and its realization due to obstacles during project implementation, which causes delays and budget overruns. Therefore, it is necessary to carry out integrated cost and time monitoring to estimate the total cost and time required until the project is completed. This monitoring aims to avoid delays and cost overruns, and can be done using the Earned Value Analysis (EVA) Method (Irawan et al., 2019). The earned value concept presents three dimensions: the physical completion of the project (the percent complete), the planned absorption of costs (budgeted cost), and the actual costs that have been incurred (actual cost), as well as what is obtained from the

costs that have been incurred (earned value) (Witjaksana & Reresi, 2012). Changes, weather in the work area, and lack of ability to manage resources can affect project activities in terms of cost and implementation time. Costs incurred in the implementation process must be anticipated to avoid cost overruns at the end of the project (Cost Overrun) (Ismail & Darkasyi, 2023; Mahapatni et al., 2022). To control the performance of the road widening project to the standard of the Bantengan Dam road section so that it does not experience delays and does not exceed the budgeted costs, the Earned Value Method is used.

The Earned Value method is an estimate of the value of completed physical work based on the Rate of Performance (RP), which is the ratio of work completed to work planned to be completed within a certain time . This method shows project performance information in the reporting period and estimates the time and cost to complete all projects based on performance indicators at the time of reporting (Nandaprasetya & Dofir, 2021). The earned value concept is a development of the Variance Analysis concept. In Variance Analysis, it only shows the work results at the reporting time compared to the budget or schedule. Earned value is calculated by multiplying the budgeted cost per job by the percentage of job completion and summing the results of all jobs in the project (Pramadha et al., 2024). The actual percentage of an activity's budget at any given time is, in general, not an indicator of the percentage of completion of that activity. By using the Earned Value Method, it is expected to know when the project ends and how much it will cost until the project is completed. This method provides important information for project performance control, helping to ensure the project goes according to plan and avoid delays and cost overruns. Thus, the use of Earned Value Method is essential for the success of construction projects, especially in conditions of limited resources and challenges faced during project implementation.

RESEARCH METHOD

This research focuses on the project of Road Widening to Standard of Bendung Bantengan Road Section in Mojokerto Regency, with the Director or Project Manager as the main subject. The research location is at coordinates 7.3842°S and 112.4457°E. Data were collected through field observations, interviews, and project documents such as time schedules, master schedules, weekly progress reports, and actual costs. These instruments provided a comprehensive picture of the project's progress and challenges encountered (Sakinah, 2021). The data collection procedure involved direct observation and interviews to obtain primary data, and project documents for secondary data. Data analysis used various techniques such as calculating job weighting (WF), cost variance (CV), schedule variance (SV), cost performance index (CPI), and schedule performance index (SPI). These techniques helped assess the cost efficiency and time performance of the project, allowing identification of potential delays or cost overruns (Sujarwo & Oetomo, 2022).

The results of the data analysis provide important insights into project management and enable the prediction of completion time and cost until the project is completed. The Earned Value Analysis method was used to calculate the Estimate Time To Complete (ETC) and Estimate Time At Complete (EAC), providing an

overview of the time and cost still required. These findings are important as an early warning tool so that project management can take corrective action to ensure the project is completed on time and within budget.

RESULT AND DISCUSSION

Project Organization Structure

The existing project organizational structure is a function organization because the preparation is carried out on the basis of the work activities of each function in accordance with the interests of the project, where each function or activity seems separate based on its field of expertise. However, each function or activity cannot stand alone because between one function and another function are interdependent.

a. **Cost Component**
   1. **Budget Cost Of Work Schedule (BCWS)**

Table 1 Recapitulation of BCWS/PV Analysis Results

Sunday	Project Budget Value	Cumulative Weight Plan	BCWS (RP)
1	IDR 4,037,886,000.00	0.008	IDR 323,030.88
2	IDR 4,037,886,000.00	0.031	IDR 1,251,744.66
3	IDR 4,037,886,000.00	0.054	IDR 2,180,458.44
4	IDR 4,037,886,000.00	0.271	IDR 10,942,671.06
5	IDR 4,037,886,000.00	1.571	IDR 63,435,189.06
6	IDR 4,037,886,000.00	4.210	IDR 169,995,000.06
7	IDR 4,037,886,000.00	7.657	IDR 309,180,931.02
8	IDR 4,037,886,000.00	7.664	IDR 309,443,393.61
9	IDR 4,037,886,000.00	7.670	IDR 309,685,666.77
10	IDR 4,037,886,000.00	11.539	IDR 465,911,476.11
11	IDR 4,037,886,000.00	16.169	IDR 652,865,597.91
12	IDR 4,037,886,000.00	24.725	IDR 998,347,124.07

Source: Processed by Researchers, 2024

From table 1 above, it can be concluded that the project has an increasing progress from week to week, characterized by an increase in the cumulative weight of the work plan and the BCWS value. Although the project budget value was fixed, the planned cost of the work that should have been completed (BCWS) increased significantly as the project progressed. This shows that the project planning is proceeding as expected and the budget spent on each work follows the set plan. However, it is important to note that the project must still be closely monitored to ensure that the realization of the work is in accordance with the planned budget.

2. Budget Cost Of Work Performance (BCWP)

Table 2 Recapitulation of BCWP/EV Analysis Results

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

Source: Processed by Researchers, 2024

Table 2 shows the results of the BCWP/EV analysis for each week of the project. In this analysis, BCWP (Budgeted Cost of Work Performed) is the value of the completed work. The BCWP value increased significantly from week to week, reflecting the consistent progress of the project. Although in the first week BCWP had no value because no work had been completed yet, from the second week to the 12th week, BCWP continued to increase as work was completed. This shows that the project is on track and the budget spent on the completed work is in line with the overall project progress.

3. ACWP (*Actual Cost of Work Performanced*)

Table 3 Recapitulation of ACWP results

Sunday	Project Budget Value	Cumulative Weight Plan	ACWP (RP)
1	IDR 3,634,097,400.00	0.000	Rp. -
2	IDR 3,634,097,400.00	0.007	IDR 254,386.82

3	IDR 3,634,097,400.00	0.013	IDR 472,432.66
4	IDR 3,634,097,400.00	0.129	IDR 4,687,985.65
5	IDR 3,634,097,400.00	1.952	IDR 70,937,581.25
6	IDR 3,634,097,400.00	4.069	IDR 147,871,423.21
7	IDR 3,634,097,400.00	6.134	IDR 222,915,534.52
8	IDR 3,634,097,400.00	6.141	IDR 223,169,921.33
9	IDR 3,634,097,400.00	6.318	IDR 229,602,273.73
10	IDR 3,634,097,400.00	7.058	IDR 256,494,594.49
11	IDR 3,634,097,400.00	10.145	IDR 368,679,181.23
12	IDR 3,634,097,400.00	18.851	IDR 685,063,700.87

Source: Processed by Researchers, 2024

Table 3 displays a recapitulation of the ACWP (Actual Cost of Work Performed) analysis results for each week of the project. ACWP is the actual cost incurred for the completed work. In this table, the ACWP value also increases from week to week, reflecting the increase in costs used to complete the work. Although in the first week ACWP has no value because no work has been completed yet, from the second week to the 12th week, ACWP continues to increase as work is completed. This shows that the costs incurred for the completed work continue to grow as the overall project progresses.

b. Variance Calculation

1. Schedule Variance (SV)

Table 4 Calculation of Time Variance Value (SV)

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

Source: Processed by Researchers, 2024

Table 4 provides the calculation of Time Variance (SV) in the project. Time Variance 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. A negative result indicates a delay in the completion of work from the planned schedule, while a positive result indicates completion ahead of schedule. For example, in the first week, the BCWP value is IDR 0 while the BCWS is IDR 323,030.88. Therefore, the SV in the first week is -Rp 323,030.88, indicating a delay in the execution of the work. From the table, it can be seen that during most weeks, the project experienced delays in the completion of work from the planned schedule. Only in the fifth week, work was completed ahead of schedule.

2. Cost Variance (CV)

Table 5 Calculation of Cost Variant Value (CV)

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

Source: Processed by Researchers, 2024

Table 5 displays the calculation of Cost Variance (CV) in the project. Cost Variance measures the difference between BCWP (Budgeted Cost of Work Performed) and ACWP (Actual Cost of Work Performed) values. CV is calculated by subtracting the ACWP value from the BCWP. If the result is positive, it indicates that the work has been performed at a lower cost than planned. For example, in the second week, BCWP is IDR 282,652.02 and ACWP is IDR 254,386.82, so the CV is IDR 28,265.20, indicating that the work was done at a lower cost than planned by IDR 28,265.20. From the table, it can be seen that during most weeks, the project

was carried out at a lower cost than planned, except in week 11, where the costs incurred exceeded those planned by Rp 40,964,353.47.

c. Performance Index Calculation
1. Schedule Performance Index (SPI)

Table 6 SPI calculation

Sunday	BCWP (Rp)	BCWS (Rp)	SPI
1	Rp. -	Rp. -	0.00
2	IDR 282,652.02	IDR 254,386.82	0.23
3	IDR 524,925.18	IDR 472,432.66	0.24
4	IDR 5,208,872.94	IDR 4,687,985.65	0.48
5	IDR 78,819,534.72	IDR 70,937,581.25	1.24
6	IDR 164,301,581.34	IDR 147,871,423.21	0.97
7	IDR 247,683,927.24	IDR 222,915,534.52	0.80
8	IDR 247,966,579.26	IDR 223,169,921.33	0.80
9	IDR 255,113,637.48	IDR 229,602,273.73	0.82
10	IDR 284,993,993.88	IDR 256,494,594.49	0.61
11	IDR 409,643,534.70	IDR 368,679,181.23	0.63
12	IDR 761,181,889.86	IDR 685,063,700.87	0.76
	Average SPI		0.63

Source: Processed by Researchers, 2024

Table 6 shows the Schedule Performance Index (SPI) calculation for the 12-week project. SPI is calculated as the ratio between BCWP (Budgeted Cost of Work Performed) and BCWS (Budgeted Cost of Work Scheduled), i.e. SPI = BCWP / BCWS. In the first week, the SPI was 0.00 as no work was 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, signaling the project was running ahead of schedule. However, from week six to week twelve, the SPI varied between 0.61 and 0.97, indicating the project was again running below the planned schedule.

The average SPI over 12 weeks was 0.63, indicating the project was running slower than the planned schedule. SPI values consistently below 1 indicate the need for evaluation and improvement in project time management.

2. Cost Performance Index (CPI)

Cost Performance Index (CPI) is used to measure 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). The CPI formula is CPI = BCWP / ACWP. In the first week, there is no data available to calculate the CPI, so the value is 0.00. However, from week two to week twelve, the CPI value was consistently at 1.11.

Table 7 CPI calculation

Sunday	BCWP (Rp)	BCWS (Rp)	CPI
1	Rp. -	Rp. -	0.00
2	IDR 282,652.02	IDR 254,386.82	1.11
3	IDR 524,925.18	IDR 472,432.66	1.11
4	IDR 5,208,872.94	IDR 4,687,985.65	1.11
5	IDR 78,819,534.72	IDR 70,937,581.25	1.11
6	IDR 164,301,581.34	IDR 147,871,423.21	1.11
7	IDR 247,683,927.24	IDR 222,915,534.52	1.11
8	IDR 247,966,579.26	IDR 223,169,921.33	1.11
9	IDR 255,113,637.48	IDR 229,602,273.73	1.11
10	IDR 284,993,993.88	IDR 256,494,594.49	1.11
11	IDR 409,643,534.70	IDR 368,679,181.23	1.11
12	IDR 761,181,889.86	IDR 685,063,700.87	1.11

Table 7 shows the calculation of CPI as follows: in the second week, the CPI is 1.11 resulting from BCWP of Rp 282,652.02 and ACWP of Rp 254,386.82. The third week also shows a CPI of 1.11 with a BCWP of IDR 524,925.18 and an ACWP of IDR 472,432.66. This pattern continues until week fourteen, with the CPI value remaining 1.11. For example, in week four, BCWP of Rp 5,208,872.94 and ACWP of Rp 4,687,985.65 resulted in a CPI of 1.11. In the fifth week, BCWP of Rp 78,819,534.72 and ACWP of Rp 70,937,581.25 resulted in the same CPI. Similarly, in the sixth, seventh, and so on until the twelfth week, BCWP and ACWP consistently produce a CPI of 1.11. This indicates that the project is highly cost-efficient, with every dollar invested producing a greater value of work than budgeted. This consistent high CPI value indicates that the project's cost management was very effective, allowing the project to generate significant cost savings throughout the project duration.

d. Calculation of Estimated Project Time and Cost

Estimating the cost or schedule of project completion based on the indicators obtained during reporting, will provide an indication of the cost at the end of the project (estimate at completion = EAC) and the estimated time of project completion (estimate all schedule = EAS).

1. Calculation of Final Estimated Project Time

A cost or schedule estimate is useful because it provides an early warning of what is likely to happen in the future, if trends at the time of reporting do not change. At the end of the review i.e. week 12, the estimated remaining work time, Estimate Temporary Schedule (ETS) is as follows:

ETS= (remaining time) / SPI

ETS = (150-84)/0.76

ETS = 66/0.76 = 87

While the estimated time of completion of all work, Estimate All Schedule (EAS)

EAS = finish time + ETS

EAS = 84 + 87

EAS = 171 days

From the above calculations, it is obtained that the processing time is 21 days longer than the planned schedule of 171 days.

2. Calculation of Final Project Cost Estimate

At the end of the review at week 12, the estimated remaining work time, Estimate Temporary Cost (ETC) is as follows:

ETC = Budget - BCWP
ETC = Rp 4,037,886,000 - Rp 761,181,889.86
ETC = IDR 3,276,704,110.14
EAC = ACWP + ETC
EAC = Rp 685,063,700.87 + Rp 3,276,704,110.14
EAC = IDR 3,961,767,811.01

From the above calculations, the final cost value is less than the contract cost.

CONCLUSION

Based on the results of the analysis that has been carried out on the project Widening Towards Standard Road Section Bendung Bantengan Mojokerto Regency, the things that can be concluded are as follows: 1. The amount of cost obtained by Estimate Temporary Cost (ETC) is IDR 3,276,704,110.14. The change in cost to complete the Estimate All Cost (EAC) project is 0.811% less than the contract cost. 2. The time required by the Estimate Temporary Schedule (ETS) at the end of the 12th week review is 87 days. While the time to complete the Estimate All Schedule (EAS) project is 171 days. So that the implementation time is 21 days longer than the estimated time.

Based on the results of the analysis that has been carried out on the project Widening Towards Standard Road Section Bendung Bantengan Mojokerto Regency so that the remaining time available does not occur over cost and work delays, the researchers provide the following suggestions: 1. Construction service providers in order to minimize the problems that occur during the work process so that they can reduce costs and speed up the work during the implementation process. 2. The results of this study are expected to provide useful information for parties involved in the implementation of construction projects to find out all the factors that cause project implementation to be disrupted. 3. The use of earned value analysis is recommended consistently at all stages of a development project. This will help improve transparency, accountability and better decision-making.

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