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Performance Analysis of the Warmadewa Educational Hospital Building Construction Project

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ABSTRACT

In a project, effective management is crucial for organizing workflow and control to achieve the project's objectives. Project management involves continuous monitoring and evaluation of project performance to ensure that all parts of the project are on track. The aim of this study is to analyze the performance of the Warmadewa Educational Hospital Building Construction Project in terms of cost and time using the Earned Value method. The data used consists of primary data obtained from field observations and interviews, as well as secondary data from weekly reports, the Budget Plan (RAB), and the project schedule. The analysis shows that the project experienced delays from the first week up to the evaluation week. The Schedule Variance (SV) and Schedule Performance Index (SPI) analysis indicates that the project is progressing slower than planned. From the Estimate To Complete (ETC) and Estimate At Completion (EAC) analyses, the project is estimated to require an additional 719 days to complete. This represents a delay of 92 days from the initial planned duration of 627 days. The Cost Variance (CV) and Cost Performance Index (CPI) analysis indicate that the project costs are within the budget.

Keywords: project performance; cost; time; earned value method

1 Introduction

Project management can be understood as the application of knowledge and the utilization of resources to achieve project goals. During the project implementation process, management plays a crucial role in organizing workflow and control to ensure the achievement of the project's main objectives [1]. Effective project management includes meeting time, budget, and scope requirements. As projects need change, management tools must also adapt [2]. Project management is a discipline and practice that includes planning, organizing, controlling, and supervising all aspects of a project, from the initial stage to completion. The main objective of project management is to achieve success by ensuring the project is completed according to the established schedule and budget and meets the planned quality standards. In this context, the focus of the analysis is on project organization, including the process of monitoring project progress, identifying and resolving arising issues, and ensuring the project continues to move towards its established goals. The main goal of project control is to ensure optimal management of project costs, time, and quality while maintaining safety standards as benchmarks. All activities in the control process include inspection, supervision, and adjustments to the project implementation [3].

The Earned Value (EV) method is an effective technique for managing projects. This method considers costs in relation to the budget based on the extent to which the work has been completed [4]. The Earned Value (EV) method is an approach used to evaluate project performance in terms of profit and loss, and it offers a way to balance and maximize gains [5]. A project management methodology called Earned Value Management (EVM) integrates scope, cost, and time and calls for regular evaluations of the work's performance and cost [6]. EVM can be considered a valuable basis for estimating the project's duration and cost [7]. An efficient way to manage project performance is through the use of the Earned Value Performance Management (EVPM) technique in project management [8]. One industry standard for tracking the progress of ongoing projects is earned value management. During the planning stage, performance baselines are established to monitor and measure any deviations from the schedule and budget throughout the project execution [9]. By utilizing EVM, a project can be completed on time and within budget, but the quality may not meet the customer's

expectations. If the final outcome does not meet the required quality, rework will be necessary, which will add costs and time, thereby extending the project's duration [2]. EVM enables early error detection and prompt action to prevent further issues from occurring [10]. In conclusion, the Earned Value Management (EVM) method is an efficient project management technique for controlling costs and time by integrating the project's scope, budget, and schedule. This method can detect errors early, enabling project managers to take swift action to prevent problems, making it a valuable tool in project management. Although EVM ensures that projects are completed on time and within budget, there is a risk of reduced quality that may require rework.

The construction project of the Warmadewa Educational Hospital Building, located on Sidan-Astina Timur Street, Sidan Village, Gianyar District, Gianyar Regency, Bali, aims to provide quality healthcare facilities to improve future health services for the community. This project is planned to be completed within 627 calendar days for structural and architectural work, starting from November 1, 2019, to July 19, 2021, with a budget of Rp 45,120,242,061.22 (forty-five billion, one hundred twenty million, two hundred forty-two thousand, sixty-one rupiahs). Throughout the construction process, careful attention to various aspects such as time, cost, and quality is crucial to ensuring everything aligns with the agreed plan.

Based on the data reported in the 10th week, the project has achieved only 7.026%, experiencing a delay of 1.161% from the planned progress of 8.178%. This delay is due to issues related to soil handling processes caused by landslides, land acquisition, and the planned relocation to Dharma Yadnya Hospital in Denpasar. Additionally, resource allocation is being divided with other ongoing projects, including the Warmadewa College (WC) project, Warmadewa Independent Shining (WISH), and the G2 Building at Warmadewa University.

Project delays diminish the contractor's credibility and incur additional costs, reducing profits. Refining the schedule and budget is crucial to avoid these issues and optimize project outcomes. The Earned Value Method has proven effective in monitoring and managing project activities [11]. This study aims to evaluate project performance in terms of cost and time, as well as to estimate the total cost and duration required to complete the project.

2   Data and Methods

2.1 Data

In this study, the construction project of the Warmadewa Educational Hospital Building is located on Sidan-Astina Timur Street, Sidan Village, Gianyar District, Gianyar Regency, Bali. The project is planned to be completed within 627 calendar days, starting from November 1, 2019, to July 19, 2021.

Primary and secondary data from the SATKER for the Warmadewa Educational Hospital Building construction are used in this study. Field observations and interview results constitute primary data, while the Budget Plan (RAB), schedule, Unit Price Analysis (AHSP), and weekly reports serve as secondary data.

2.2 Methods

This study uses a quantitative method. This approach is applied in Earned Value Analysis to evaluate project performance by measuring the actual value of completed work against the established budget. Earned Value Management is the most commonly used system in construction projects worldwide for integrating time and cost control [12].

The steps taken to complete this analysis are as follows:

1. Process the obtained data to analyze indicators from the Earned Value Method, such as BCWS, BCWP, dan ACWP.
2. Analyze project performance in terms of execution time using indicators such as SV, SPI, ETS, dan EAS.
3. Analyze project performance related to execution costs using indicators such as CV, CPI, ETC, dan EAC.
4. Draw conclusions based on the results of the analysis conducted.

PV (Planned Value), AC (Actual Cost), and EV (Earned Value) are the three primary parts of the Earned Value Management (EVM) technique. The percentage of work accomplished for each task in relation to the allocated budget is used to compute EV. EV reflects the efficiency of resource use in the project. [13]. Here is an explanation of the three key indicators of the Earned Value approach:

1. Budgeted Cost of Work Schedule

The entire cost that is anticipated to be incurred in accordance with the project's defined plan at a particular point in time is called BCWS, or Planned Value (PV). The entire budgeted cost for the work that is expected to be finished in a given amount of time is added up to determine BCWS [14].

$$\text{BCWS} = (\text{Percentage of Planned Work}) \times \text{Contract Value (RAB)} \qquad (1)$$

2. Budgeted Cost of Work Perfomance

Earned worth (EV), commonly referred to as BCWP, is the worth of the work that has been finished in a given amount of time. The budgeted cost of the completed work is added together to determine the BCWP, which represents the value of the work that has been successfully performed [14].

$$\text{BCWP} = (\text{Percentage of Completed Work}) \times \text{Contract Value (RAB)} \qquad (2)$$

3.   Actual Cost of Perfomance

ACWP, also known as Actual Cost (AC), is the actual cost incurred to complete a specific amount of work within a given period. It represents the total expenses spent on the work performed up to that point in time [14].

$$ACWP = \text{Actual Costs Incurred} \qquad (3)$$

The Earned Value method, based on these indicators, is used to evaluate project performance, including variance analysis, performance index analysis, and forecasting the final cost and completion time of the project.

1.   Variance Analysis

a.   Cost Variance

The difference between the project's actual costs (AC) and its earned value (EV) after completion is known as the cost variance (CV) [5]. Whereas a negative cost variance denotes that actual costs were greater than initial estimates, a positive cost variance shows that actual costs were lower than projected expenses [15].

$$CV = BCWP - ACWP \qquad (4)$$

b.   Schedule Variance

The difference between Planned Value (PV), also called Budgeted Cost of Work Scheduled (BCWS), and Earned Value (EV), sometimes called Budgeted Cost of Work Performed (BCWP), is determined using Schedule Variance (SV) [5]. When the earned value of the work completed falls short of the intended value, there is a negative schedule variance, which means the project is running behind schedule. On the other hand, a positive schedule variance indicates that the project is progressing more quickly than expected, with earned value surpassing anticipated value [15].

$$SV = BCWP - BCWS \qquad (5)$$

Table 1 shows the interpretation of variance analysis results based on different combinations of Schedule Variance (SV) and Cost Variance (CV) values.

Table 1. Variance Analysis

No	SV	CV	Description
1	Positive	Positive	The work is completed earlier than planned and at a lower cost than budgeted.
2	Zero	Positive	The work is completed on time and at a lower cost than initially planned.
3	Positive	Zero	The work was completed within the budget and ahead of the planned schedule.
4	Zero	Zero	The work was successfully completed on time and within the established budget.
5	Negative	Negative	The work is completed not according to the scheduled timeline and the costs exceed the established budget.

No	SV	CV	Description
6	Zero	Negative	The work was completed on time but exceeded the budgeted costs.
7	Negative	Zero	The work was completed in a longer time, but still within the budget.
8	Positive	Negative	The work was completed earlier than scheduled but at a cost that exceeded the budget.
9	Negative	Positive	The work is completed later than scheduled, but at a lower cost than budgeted.

2.   Perfomance Index Analysis

a.   CPI (Cost Perfomance Index)

By comparing the physical value of the work accomplished (BCWP) with the costs incurred during the same period (ACWP), the CPI is a measure of cost efficiency [5].

$$CPI = \frac{BCWP}{ACWP} \qquad (6)$$

b.   SPI (Schedule Perfomance Index)

SPI compares the Earned Value (BCWP) to the Budgeted Cost of Work Scheduled (BCWS) to determine how effectively work has been accomplished [5].

$$SPI = \frac{BCWP}{BCWS} \qquad (7)$$

Project performance can be evaluated using two key performance indices: Cost Performance Index (CPI) and Schedule Performance Index (SPI). Table 2 presents the interpretation of these indices based on their calculated values. These indices provide quantitative measures of project efficiency in terms of cost utilization and schedule adherence.

Table 2. Perfomance Index Analysis

Index	Value	Description
CPI	>1	The actual cost incurred for the work is less than the value earned from that work.
	<1	The Actual Cost (ACWP) incurred exceeds the Earned Value (BCWP) of the completed work.
	=1	The Actual Cost of Work Performed (ACWP) is proportional to the value of the work that has been completed (BCWP).
SPI	>1	The work was completed earlier than planned.
	<1	The project execution is slower than planned.
	=1	The project's performance is consistent with the planned schedule.

3.   Cost and Schedule Estimation Analysis

a.   ETC (Estimate to Complete)

Pahalawan (2015) in [4] states that ETC is the estimate of the cost for the work that remains to be done.

$$ETC = \frac{(BAC - BCWP)}{ACWP} \qquad (8)$$

b. **EAC (Estimate at Completion)**
Pahalawan (2015) in [4] states that EAC is the total estimated cost of the project.

$$EAC = ACWP + ETC \qquad (9)$$

c. **ETS (Estimate to Schedule)**
Ramdhani (2016) in [4] states that ETS is the estimate of the time required to complete the remaining work.

$$ETS = \frac{(SAC - tBCWP)}{SPI} \qquad (10)$$

d. **EAS (Estimate at Schedule)**
Ramdhani (2016) in [4] states that EAS is the estimate of the total project completion time.

$$EAS = tBCWP + ETS \qquad (11)$$

The project work consists of a series of tasks that must be completed according to the contract and within the previously agreed-upon costs. Time and cost are critical components in project management control. All contractors who take on a project expect it to be completed on schedule [16].

3   Results and Discussion

This study evaluates project performance by conducting a review in the 10th week. Based on the available data, it is assumed that the value of ACWP is equal to the value of BCWP. The value of BCWS is recorded as Rp 3,694,101,113.71, and the value of BCWP is Rp 3,170,078,835.92. Figure 1 illustrates the results of the earned value indicator analysis from the first week to the 10th week.
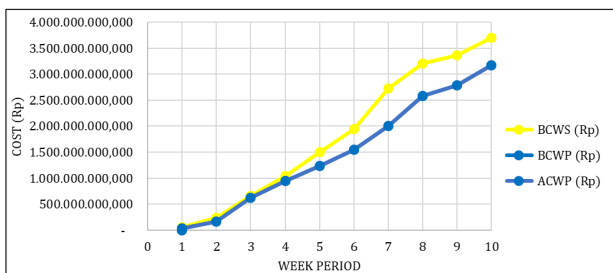

Figure 1. Illustration of the results from Earned Value indicators analysis

In Figure 1, the graph uses the vertical axis to show the total cost in Rupiah and the horizontal axis to indicate the weekly periods. The yellow line represents the project's planned cost, while the blue line depicts the actual expenditure for completed work. This graph illustrates that the incurred costs are lower than the planned costs, indicating that either less work has been completed or there have been delays from the scheduled timeline.

3.1   Time Analysis

1. **SV (Schedule Variance)**

Based on Table 3, the results of the schedule variance analysis from the first week to the 10th week are negative. This indicates that the project has been delayed since the first week, suggesting that the project execution is not in line with the planned schedule. The SV value can be calculated using the formula in Equation 5.

Table 3. Summary of SV Calculation

Week Period	BCWP (Rp)	BCWS (Rp)	SV (Rp)
1	32.900.000	55.542.375,00	- 22.642.375,00
2	162.684.750,00	237.684.750,00	- 75.000.000,00
3	619.448.600,00	661.270.750,00	- 41.822.150,00
4	946.847.450,00	1.050.031.200,00	- 103.183.750,00
5	1.240.959.450,00	1.501.993.676,67	- 261.034.226,67
6	1.552.412.830,00	1.951.633.806,72	- 399.220.976,72
7	2.002.989.766,34	2.724.754.748,77	- 721.764.982,43
8	2.585.016.426,68	3.204.619.668,21	- 619.603.241,53
9	2.790.998.039,47	3.369.064.207,35	- 578.066.167,88
10	3.170.078.835,92	3.694.101.113,71	- 524.022.277,79

2. **SPI (Schedule Perfomace Index)**

Based on Table 4, the analysis of the Schedule Performance Index from the first week to the 10th week shows values of less than 1. This indicates that the project's performance is slower compared to the planned schedule. The SPI value can be calculated using the formula in Equation 7.

Table 4. Summary of SPI Calculation

Week Period	BCWP (Rp)	BCWS (Rp)	SPI
1	32.900.000,00	55.542.375,00	0,59
2	162.684.750,00	237.684.750,00	0,68
3	619.448.600,00	661.270.750,00	0,94
4	946.847.450,00	1.050.031.200,00	0,90
5	1.240.959.450,00	1.501.993.676,67	0,83
6	1.552.412.830,00	1.951.633.806,72	0,80
7	2.002.989.766,34	2.724.754.748,77	0,74
8	2.585.016.426,68	3.204.619.668,21	0,81
9	2.790.998.039,47	3.369.064.207,35	0,83
10	3.170.078.835,92	3.694.101.113,71	0,86

3. **ETS (Estimate to Schedule)**

Based on Table 5, the estimate to schedule analysis shows that completing the remaining work of the project at the 10th-week review is expected to

require approximately 649 days. This indicates an extension of time from the plan, and a comparison with the initial schedule shows a significant delay. The ETS value can be calculated using the formula in Equation 10.

Table 5. Summary of ETS Calculation

Week Period	SPI	Contract Plan Time (Day)	Time Elapsed (Day)	Remaining Time (Day)	ETS (Day)
1	0,59	627	7	620	1047
2	0,68	627	14	613	896
3	0,94	627	21	606	647
4	0,90	627	28	599	664
5	0,83	627	35	592	717
6	0,80	627	42	585	735
7	0,74	627	49	578	786
8	0,81	627	56	571	708
9	0,83	627	63	564	681
10	0,86	627	70	557	649

4. **EAS (Estimate at Schedule)**

Based on the estimate at schedule analysis results in Table 6, the estimate for week 10 shows that the project is expected to require approximately 719 days to complete. The EAS value can be calculated using the formula in Equation 11.

Table 6. Summary of EAS Calculation

Week Period	Contract Plan Time (Day)	Time Elapsed (Day)	ETS (Day)	EAS (Day)
1	627	7	1047	1054
2	627	14	896	910
3	627	21	647	668
4	627	28	664	692
5	627	35	717	752
6	627	42	735	777
7	627	49	786	835
8	627	56	708	764
9	627	63	681	744
10	627	70	649	719

3.2 Cost Analysis

1. **CV (Cost Variance)**

The analysis results of cost variance from the first week to the tenth week show a value of zero. This indicates that the budget has been adjusted to match the actual work performed. Equation 4 provides the formula used to calculate the CV value.

2. **CPI (Cost Perfomance Index)**

The analysis of the cost performance index from the first week to the tenth week shows a value of 1; this indicates that the costs incurred are in line with

the plan. Equation 6 contains the formula that can be used to calculate the CPI value.

3. **ETC (Estimate to Complete)**

Table 7 indicates that the analysis for the 10th week review's estimate of completion indicates that Rp 41,950,163,225.30 will be needed in total to finish the project's remaining work. The formula found in Equation 8 can be used to determine the ETC value.

Table 7. Summary of ETC Calculation

Week Period	BCWP (Rp)	CPI	ETC (Rp)
1	32.900.000,00	1,00	45.087.342.061,22
2	162.684.750,00	1,00	44.957.557.311,22
3	619.448.600,00	1,00	44.500.793.461,22
4	946.847.450,00	1,00	44.173.394.611,22
5	1.240.959.450,00	1,00	43.879.282.611,22
6	1.552.412.830,00	1,00	43.567.829.231,22
7	2.002.989.766,34	1,00	43.117.252.294,88
8	2.585.016.426,68	1,00	42.535.225.634,54
9	2.790.998.039,47	1,00	42.329.244.021,75
10	3.170.078.835,92	1,00	41.950.163.225,30

4. **EAC (Estimate at Complete)**

Based on the analysis conducted, the estimated completion cost is Rp 45,120,242,061.22. This value indicates that the total estimated cost to complete the project will stay within the budget. The formula found in Equation 9 can be used to calculate the EAC value.

4 Conclusion

After conducting a performance analysis of the Warmadewa Educational Hospital Building construction project using the Earned Value method, the following conclusions were drawn:
1. The project has experienced delays from the first week to the tenth week based on the review.
2. The project performance analysis results show a negative SV and a CV of zero, indicating that the project was completed late, but the expenditures were in line with the decided budget.
3. HThe project performance analysis shows that the SPI is less than 1, indicating that the project will be behind the planned schedule. On the other hand, the CPI is 1, which indicates that the actual cost incurred (ACWP) is equal to the earned value (BCWP).
4. The estimated time required for the remaining work to be completed (ETS) is approximately 649 days. Meanwhile, to complete the entire project (EAS), it is estimated to take a total of about 719 days. This indicates that the project is experiencing a delay of 92 days compared to the initial planned duration of 627 days.

For future research, it is recommended to investigate mitigation strategies for identified delay factors and develop integrated cost – schedule - quality performance metrics.

5   Acknowledgement

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