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ANALYSIS OF COST AND TIME USING EARNED VALUE ON THE BOARDING SCHOOL CONSTRUCTION PROJECT AT SMA MUHAMMADIYAH 3 TULANGAN SIDOARJO

Titik Nurkaruniati[1], Budi Witjaksana[2], Hanie Teki Tjendani[3]
[1,2,3] Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: titiknia25@gmail.com, budiwitjaksana@untag-sby.ac.id, hanie@untag-sby.ac.id

ABSTRACT

Effective project management is crucial for the successful completion of construction projects, including the construction of a dormitory at SMA Muhammadiyah 3 Tulangan. Challenges such as design changes, adverse weather conditions, and limited labor resources impact the project's progress. The Earned Value Method is used to monitor project performance by analyzing indicators like BCWS, BCWP, ACWP, SV, CV, SPI, and CPI. This analysis shows that the project initially experienced delays and exceeded budget costs, but the situation improved significantly over time. Despite weekly variations in costs, the project remained on a financially manageable track. The conclusion from this analysis is that while the project faced time delays, cost performance remained under control. Recommendations for improvement include more thorough planning, better resource management, and quicker responses to changes.

KEYWORDS *Boarding School Construction, Project Performance Evaluation, Earned Value Method*

INTRODUCTION

The series of activities in planning, scheduling, and controlling the course of a project aims to achieve the desired goals, both in terms of time, quality, and cost (Rifatul Muniroh et al., 2021). In the context of MBS dormitory construction, project management is very important to ensure that construction goes according to plan and on time. However, there is often a mismatch between the initial plan and the realization in the field, which can result in delays and increased costs on the project. One of the problems that often arise is scheduling planning that does not take into account the limited labor resources, which must be carefully analyzed (Pratama S et al., 2022). To overcome scheduling with limited resources, a

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systematic effort is needed to determine standards that are in accordance with planning objectives or take into account the possibility of deviations between implementation and project standards. This should be done at the beginning and end of project construction, known as project control (Pratama et al., 2022).

In 2023, SMA Muhammadiyah 3 Tulangan launched the Muhammadiyah Boarding School (MBS) program, which requires the school to provide dormitories for students. However, the significant increase in the number of MBS students caused the existing dormitories to be insufficient. To overcome this, it was decided to build a new dormitory that could accommodate more students. CV. Tiga Anugerah Utama was appointed as the provider to work on the construction of this new dormitory. The contract for the construction of the dormitory started on November 23, 2023 and is expected to be completed on May 26, 2024, in order to be used at the start of the new academic year in June 2024. During the project implementation, various obstacles affected the course of the project, one of which was the design changes made midway without changing the contract value, but only by making a Contract Change Order (CCO). These changes included changes to the building structure and room additions, which had implications on the cost and time of project implementation.

Erratic weather, especially frequent rains in Sidoarjo, was also a factor that slowed down project progress. Workers could not work optimally due to unfavorable weather conditions, and material delivery was hampered due to slippery roads leading to the project site. This led to increased costs and delays in project implementation. Another obstacle faced was the lack of professional labor in the field and the lack of ability to manage existing resources optimally. This affected the efficiency and productivity of work in the field, and potentially caused delays in project completion. The decision not to purchase new materials for the formwork also slowed down the construction process, despite having the potential to save costs.

Although the original contract was only to build the ground floor, the contractor decided to continue the construction up to the third floor with a loan from the contractor and approval from the school. This was done without changing the timing of the project, but still ensured that the building could be used in the new school year. In the face of these challenges, a method is needed that can help in controlling the cost and time of the project. One of the methods used is the Earned Value Method, which integrates cost and time to evaluate project performance. This method allows project planners to predict the length of time required until the project is completed and know the amount of costs incurred until the project ends. Thus, the use of the Earned Value Method is expected to assist in controlling the performance of the MBS dormitory construction project of SMA Muhammadiyah 3 Tulangan, as well as ensuring that the project can be completed on time and in accordance with the predetermined budget.

The Earned Value method is one of the tools used in project management that integrates cost and time. The Earned Value method presents three dimensions, namely the physical completion of the project (the percent complete) which reflects the planned absorption of costs (budgeted cost), the actual costs that have been incurred or what is called Actual Cost and what is obtained from the costs that have

been incurred. It is hoped that by using the Earned Value Method, researchers will predict the length of time needed until the project ends in accordance with the contract period and know the amount of costs incurred until the project ends. From the background above, the following problem formulation can be made:

1. What is the time performance (Schedule Variance), time productivity index (Schedule Performed Index), and estimated total project implementation time (Estimated at Schedule)?
2. How is cost performance seen from indicators (Cost Variance), cost productivity index (Cost Performed Index) and estimated total cost of project implementation (Estimated All Completion) ?

RESEARCH METHOD

The research method for the Muhammadiyah Boarding School Construction project at SMA Muhammadiyah 3 Tulangan is a structured process that aims to analyze project performance and accurately estimate the cost and time to complete the project. This process involves steps such as determining the project background, literature review to deepen understanding, data collection through Time Schedule, Cost Budget Plan (RAB), weekly progress reports, and actual costs. These data become the basis for analyzing project performance by calculating indicators such as BCWS (Budgeted Cost of Work Scheduled), BJWP (Budgeted Cost of Work Performed), ACWP (Actual Cost of Work Performed), CV (Cost Variance), SV (Schedule Variance), CPI (Cost Performance Index), and SPI (Schedule Performance Index). Calculation of cost estimates and project completion times using predetermined formulas based on the data that has been collected.

These estimates are important to provide an accurate picture of the resource requirements and expected project schedule. Afterwards, the researcher summarizes the project performance and provides cost and time estimates for project completion as a basis for stakeholders. The method was carefully designed to ensure proper data collection and in-depth analysis to provide a comprehensive understanding of the project performance. This method ensures that the MBS dormitory construction project of SMA Muhammadiyah 3 Tulangan can be run efficiently and in accordance with the established plan.

There are several stages in analyzing project performance, the first is determining the values of planed value, earned value, actual cost, schedule variance, cost variance, schedule performance index, cost performance index, estimate to complete, estimate at complete, and time estimated.

- BCWS (Bugeted Cost of Work Scheduled) is the amount of budgeted costs for work scheduled for a certain period of time and which is specified in the budget, obtained by multiplying the percentage of progress plans contained in the time schedule with the project implementation costs listed in the RAB. The BCWS value is calculated using equation 2.3.
- BCWP (budgeted cost of work performed) is the amount of costs incurred, for work that has been carried out, obtained by multiplying the percentage

of progress that has been carried out by the budget BCWP value is calculated using equation 2.2.

- ACWP (Actual Cost Of Work Performed) is the actual cost expenditure, of the work that has been done up to a certain period of time. These costs are obtained from accounting data on the reporting date, records of all direct costs, non-overhead costs and other costs. This calculation is only an estimate or estimate that is assumed to be the real cost used. ACWP = (Weight of implementation per week / Weight of overall plan) x Total Budget Cost The BCWS value is calculated using equation 2.1.
- CV (Cost Variance) / Cost variance, the difference between the cost provided for the work that has been done (BCWP) and the actual cost of the work that has been carried out (ACWP) and the integrated schedule, it has been mentioned earlier that analyzing project progress with simple variance analysis is considered insufficient, because this method does not integrate aspects of cost and schedule. To overcome this, BCWS, BCWP, and ACWP indicators are used in determining Cost Variance and Schedule Variance in an integrated manner. Cost Variance (CV) and Schedule Variance (SSV) are calculated by equation 2.4.
- CPI (Cost Performed Index)/ Cost Productivity and Performance Index, a comparison between the budgeted cost of the work activities performed (BCWP) and the actual cost of the work activities performed (ACWP). Project managers often want to know the efficiency of resource use, which can be expressed as a productivity index or performance index. This performance index consists of the Cost Performance Index (CPI) and Schedule Performance Index (SPI). CPI is calculated by equation 2.6 and SPI is calculated by equation 2.7.
- Projected Cost Expenditure and Project Completion Timeframe, making a cost forecast or project completion schedule based on the indicators obtained at the time of reporting, will provide an indication of the amount of cost at the end of the project (Estimate At Completion = EAC) calculated by equation 2.10 and the estimated project completion time (Estimate All Schedule = EAS) calculated by equation 2.12. Cost or schedule forecasts are very useful because they provide an early warning of things that will happen in the future, if the trends that exist at the time of reporting do not change. If the remaining work is considered to be performing as it was at the time of reporting,
- After obtaining the calculation of the amount of cost at the end of the project (Estimate At Completion = EAC) calculated by equation 2.10 and the estimated project completion time (Estimate Time Schedule = ETS) calculated by equation 2.11, the calculation continues by calculating the

amount of cost needed to complete the project without any additional time assuming that the estimated project completion time (Estimate All Schedule = EAS) is the same as the Implementation Time Plan (T total) calculated using formula 2.12.

RESULT AND DISCUSSION

Discussion

Recapitulation of BCWS, BCWP, and ACWP calculation results

In monitoring the progress of the Muhammadiyah Boarding School Dormitory Construction project at SMA Muhammadiyah 3 Tulangan, we use important indicators such as BCWS, BCWP, and ACWP. The weekly data in Table 1 provides an overview of the planning and cost realization during the first 15 weeks of project implementation. From this data, we can evaluate the project's adherence to the cost plan and understand the cost realization of the project.

Table 1 Recapitulation of BCWS, BCWP, and ACWP calculation results

Week To	BCWS	BCWP	ACWP
1	4.484.442,31	3.000.000,00	246.080.500,00
2	75.804.683,86	8.753.500,00	251.280.500,00
3	174.349.730,08	64.032.401,31	336.130.600,00
4	272.894.776,30	133.470.044,19	359.524.000,00
5	371.439.822,52	298.420.282,61	397.366.068,00
6	457.735.391,43	477.083.229,15	430.143.568,00
7	586.159.877,02	626.295.393,18	464.850.218,00
8	769.244.924,76	865.650.315,09	489.217.218,00
9	1.033.135.158,57	1.055.757.015,95	594.681.718,00
10	1.299.107.250,20	1.227.673.105,24	650.083.718,00
11	1.502.795.964,89	1.396.394.111,75	667.422.118,00
12	1.685.502.190,22	1.580.565.545,74	691.585.018,00
13	1.868.208.415,55	1.951.272.869,19	869.537.474,00
14	2.050.914.640,87	2.021.090.443,09	963.930.274,00
15	**2.396.739.592,51**	**2.204.079.461,19**	**997.423.774,00**

Source: Processed by Researchers, 2024

The data in Table 1 shows an improvement in the project's cost performance and efficiency after the initial few weeks that showed high actual costs compared to the planned budget. Although some challenges remained until the last week analyzed, the project gradually showed improvements in cost management and job efficiency.

Calculation of Schedule Variance (SV) and Cost Variance (CV) Values

To monitor the progress of the Muhammadiyah Boarding School Dormitory Construction project at SMA Muhammadiyah 3 Tulangan, we calculate Schedule Variance (SV) and Cost Variance (CV). SV measures schedule variances, while CV shows cost variances. Table 2 displays the weekly values of SV and CV, where negative values indicate delays and cost overruns, while positive values indicate the project is running on or ahead of schedule with costs under budget.

Table 2 Schedule Variance (SV) Value and Cost Variance (CV) Value

Week To	SV	Description	CV	Description
1	-1.484.442,31	Negative	-243.080.500,00	Negative
2	-67.051.183,86	Negative	-242.527.000,00	Negative
3	-110.317.328,77	Negative	-272.098.198,69	Negative
4	-139.424.732,11	Negative	-226.053.955,81	Negative
5	-73.019.539,92	Negative	-98.945.785,39	Negative
6	19.347.837,70	Positive	46.939.661,15	Positive
7	40.135.516,14	Positive	161.445.175,18	Positive
8	96.405.390,31	Positive	376.433.097,09	Positive
9	22.621.857,36	Positive	461.075.297,95	Positive
10	-71.434.145,00	Negative	577.589.387,24	Positive
11	-106.401.853,17	Negative	728.971.993,75	Positive
12	-104.936.644,52	Negative	888.980.527,74	Positive
13	83.064.453,60	Positive	1.081.735.395,19	Positive
14	-29.824.197,83	Negative	1.057.160.169,09	Positive
15	-192.660.131,37	Negative	1.206.655.687,19	Positive

Source: Processed by researchers, 2024.

In table 2 it is found that weeks 1-5, the project is delayed and costs are over budget (negative SV and CV). In weeks 6-9, the project was on schedule and costs were under budget (SV and CV positive). Weeks 10-12 showed delays but costs were under control (negative SV, positive CV). Week 13, the project was back on schedule and cost (SV and CV positive). However, in weeks 14-15, the project again experienced delays although costs remained under control (negative SV, positive CV).

Calculation of Schedule Performance Index (SPI) and Cost Performance Index (CPI)

To monitor the progress of the Muhammadiyah Boarding School Dormitory Construction project at SMA Muhammadiyah 3 Tulangan, we calculated the Schedule Performance Index (SPI) and Cost Performance Index (CPI). SPI measures time efficiency by comparing planned work to that completed, while CPI measures cost efficiency by comparing budgeted costs to those incurred. Table 3 displays the weekly SPI and CPI values. SPI and CPI values less than 1 indicate low time and cost efficiency, while values greater than 1 indicate high efficiency.

Table 3 Schedule Performance Index (SPI) and Cost Performance Index (CPI)

Week To	SPI	Description	CPI	Description
1	0,6690	Not on Target	0,0122	Poor Cost Performance
2	0,1155	Not on Target	0,0348	Poor Cost Performance
3	0,3673	Not on Target	0,1905	Poor Cost Performance
4	0,4891	Not on Target	0,3712	Poor Cost Performance
5	0,8034	Not on Target	0,7510	Poor Cost Performance
6	1,0423	On Target	1,1091	Good Cost Performance
7	1,0685	On Target	1,3473	Good Cost Performance
8	1,1253	On Target	1,7695	Good Cost Performance
9	1,0219	On Target	1,7753	Good Cost Performance
10	0,9450	Not on Target	1,8885	Good Cost Performance
11	0,9292	Not on Target	2,0922	Good Cost Performance
12	0,9377	Not on Target	2,2854	Good Cost Performance
13	1,0445	On Target	2,2440	Good Cost Performance
14	0,9855	Not on Target	2,0967	Good Cost Performance
15	0,9196	Not on Target	2,2098	Good Cost Performance

Source: Processed by researchers, 2024.

The SPI and CPI data showed that the project experienced initial challenges in achieving targets, particularly in terms of time delays and poor cost performance. However, over time, project performance began to improve, with better target achievement and cost performance. Although there were some periods with time performance challenges, cost performance was well maintained throughout the project.

Calculation of Estimate to Sechedule (ETS), Estimate At Sechedule (EAS) and Remaining Cost Estimate To Complete (ETC)

The performance evaluation of the Muhammadiyah Boarding School Dormitory Construction project at SMA Muhammadiyah 3 Tulangan requires regular analysis of the Cost Budget Plan (RAB), Earned Value (BCWP), Cost Performance Index (CPI), and estimated remaining cost (ETC). The table contains weekly data related to RAB, BCWP, CPI, and ETC during the project period.

Table 4 Value of Estimate to Sechedule (ETS), Estimate At Sechedule (EAS) and Remaining Cost Estimate To Complete (ETC)

Sunday	RAB	BCWP	CPI	ETC
	1	2	3	3 = 1 -2➔ (<50%) 4= (1-2)/3➔ (>50%)
1	5.617.188.890,13	3.000.000,00	0,0122	5.614.188.890,13
2	5.617.188.890,13	8.753.500,00	0,0348	5.608.435.390,13

3	5.617.188.890,13	64.032.401,31	0,1905	5.553.156.488,82
4	5.617.188.890,13	133.470.044,19	0,3712	5.483.718.845,94
5	5.617.188.890,13	298.420.282,61	0,7510	5.318.768.607,52
6	5.617.188.890,13	477.083.229,15	1,1091	5.140.105.660,98
7	5.617.188.890,13	626.295.393,18	1,3473	4.990.893.496,95
8	5.617.188.890,13	865.650.315,09	1,7695	4.751.538.575,04
9	5.617.188.890,13	1.055.757.015,95	1,7753	4.561.431.874,18
10	5.617.188.890,13	1.227.673.105,24	1,8885	4.389.515.784,89
11	5.617.188.890,13	1.396.394.111,75	2,0922	4.220.794.778,38
12	5.617.188.890,13	1.580.565.545,74	2,2854	4.036.623.344,39
13	5.617.188.890,13	1.951.272.869,19	2,2440	3.665.916.020,94
14	5.617.188.890,13	2.021.090.443,09	2,0967	3.596.098.447,04
15	5.617.188.890,13	2.204.079.461,19	2,2098	3.413.109.428,94

Source: Processed by researchers, 2024.

The project underwent significant changes from start to finish. Initially, low performance was evident from low CPI values and high estimated residual costs. However, over time, performance improved consistently, characterized by increased CPI values and decreased residual cost estimates. This indicates improved project cost management over time, resulting in more efficient performance in budget management.

Calculation of Total Final remaining cost Estimate At Complete (EAC)

In the Muhammadiyah Boarding School Dormitory Construction project of SMA Muhammadiyah 3 Tulangan, it is important to monitor actual expenditure (ACWP), estimated residual cost (ETC), and estimated cost at the end of the project (EAC) to evaluate performance and cost projections. Weekly data related to ACWP, ETC, and EAC have been presented in the following table.

Table 5 EAC (Estimate at Complete) Value

Sunday	ACWP	ETC	EAC
	1	2	3= 1 +2
1	246.080.500,00	5.614.188.890,13	5.860.269.390,13
2	251.280.500,00	5.608.435.390,13	5.859.715.890,13
3	336.130.600,00	5.553.156.488,82	5.889.287.088,82
4	359.524.000,00	5.483.718.845,94	5.843.242.845,94
5	397.366.068,00	5.318.768.607,52	5.716.134.675,52
6	430.143.568,00	5.140.105.660,98	5.570.249.228,98
7	464.850.218,00	4.990.893.496,95	5.455.743.714,95
8	489.217.218,00	4.751.538.575,04	5.240.755.793,04
9	594.681.718,00	4.561.431.874,18	5.156.113.592,18
10	650.083.718,00	4.389.515.784,89	5.039.599.502,89
11	667.422.118,00	4.220.794.778,38	4.888.216.896,38
12	691.585.018,00	4.036.623.344,39	4.728.208.362,39

13	869.537.474,00	3.665.916.020,94	4.535.453.494,94
14	963.930.274,00	3.596.098.447,04	4.560.028.721,04
15	**997.423.774,00**	**3.413.109.428,94**	**4.410.533.202,94**

Source: Processed by researchers, 2024.

It can be seen that the project experienced significant cost variations over time. Initially, the estimated residual cost (ETC) and estimated cost at the end of the project (EAC) tended to increase, signaling a possible shift to higher-than-expected project costs. However, over time, there was a significant decrease in ETC and EAC, indicating better cost control and efficiency in project expenditure. Despite significant weekly cost variations, the project remained on a financially manageable path and made it possible to achieve the cost target at the end of the project.

CONCLUSION

Based on the Earned Value analysis that has been calculated in Chapter 4, the conclusions that can be drawn are: 1. The time performance showed project delays, with a negative Schedule Variance (-) and a Schedule Performance Index (SPI) below 1. The estimated total project execution time was 187 days, longer than the original plan of 180 days. 2. Cost performance shows a positive (+) result with a Cost Variance of Rp. 1,206,655,687. This indicates that the project cost in week 15 is lower than the budget, with a Cost Performance Index (CPI) of more than 1. The estimated total cost of project implementation is Rp. 4,367,677,048.32.

Based on the above conclusions, there are several suggestions that can be given, among others: 1. Further analysis needs to be carried out regarding project delays and acceleration. by using the *Precedence Diagramming Method* (PDM) method to find out the forward and backward calculations for calculating the length of project work time. 2. Further analysis of the structure and quality of work is needed so that the building survives as planned.

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