Performance Evaluation of Projects using Earned Value Concept

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Abstract

The construction project is one of the jobs that demands the final result to align with the planning, necessitating a check on the performance obtained during the project to address any deviations from the initial plan. The Earned Value method is one of the techniques that can be used to assess project performance based on cost and time. The objective of implementing an evaluation with the Earned Value method is to understand the project's performance based on value variances and performance indexes and to identify solutions as early as possible if the project is experiencing delays. Calculations using the Earned Value method are based on budgeted cost of work scheduled (BCWS), cost for work performed (BCWP), and actual cost of work performed (ACWP). The research results on the Gunung Anyar apartment project reveal that the project experienced a delay of 3 weeks from the initial plan and a cost overrun of IDR 21,863,495,000 from the budget of IDR 19,533,411,725 (-12%). From the evaluation, it is evident that the Earned Value method needs to be applied during the ongoing project, especially when facing delays, to find solutions as early as possible to overcome the issues and prevent further significant losses.

Keywords: *Earned Value Method, Performance Evaluation, Project based, value concept*

1. Introduction

The construction of a construction project is an ongoing civil engineering task that demands the final result to align with the initial planning. The success or failure of a project can be attributed to the effectiveness of its control, impacting the project's overall efficiency. Project issues typically revolve around cost and time factors. Both cost and time in a project are interdependent [1]. Accurate estimation of cost and time in a project requires optimization to minimize potential risks. Therefore, an appropriate method is needed to address and minimize risks in project work as a check on the performance obtained during the execution process.

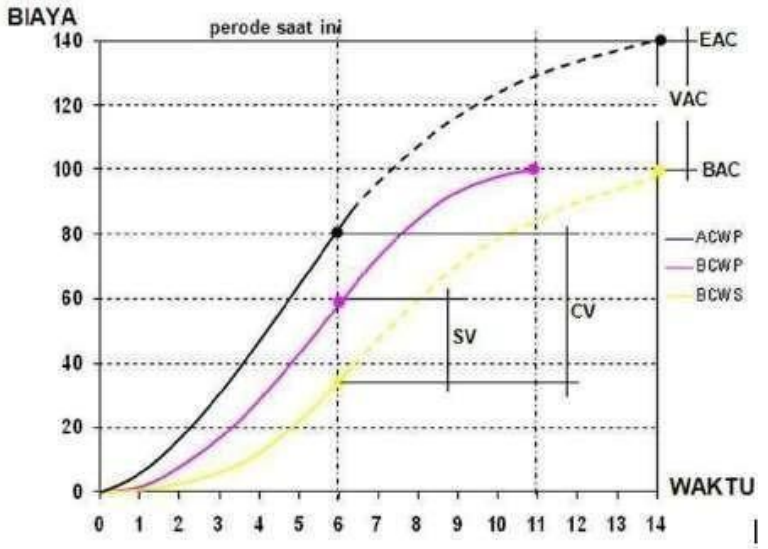

Figure 1. The Earned Value "S" Curve Graph [2]

The EV concept is one such method that can be employed to assess a project's performance based on cost and time. Earned value is a technique that utilizes specific assumptions to forecast the future state of a project, combining cost and time to assist project management teams in evaluating performance and progress. It serves as a tool to check whether the outcomes align with the initial plan or not [2][3][4]. The earned value method can be used to provide information about the project's progress and estimate progress in subsequent periods, particularly regarding cost and project completion time. Simple methods like EV are easily implementable with comprehensive data collection during the calculation process [5]. Compared to other methods, EV analysis has the advantage of depicting the project's progress on-site concerning the budgeted cost planned for the work [6]. The EV, also known as the Earned Value Management (EVM) concept, connects cost and time to assess the project's status by calculating the budgeted cost of the work performed [2]. This method can demonstrate project performance based on time and cost. The use of the EV method in performance assessment is illustrated in Figure 1, reflects as S curve graph on the construction.

The construction of an apartment building involves the construction of multi-story buildings in a densely populated and functionally structured environment, requiring precision and timely completion in accordance with the time schedule and cost expenditures allocated. Therefore, in the research on the Gunung Anyar apartment project, the EV method can be applied to assess performance during the ongoing work by examining the delays in progress and cost overruns incurred [7].

The application of the EV method in the research on the Gunung Anyar apartment faced challenges due to difficult project access or even temporary project suspension caused by the implementation of Large-Scale Social Restrictions (PSBB) during the COVID-19 pandemic, especially in high-risk or red zone areas such as Surabaya. This situation resulted in the EV method being applicable only after the project's completion. According to the obtained reports, it was found that the project, initiated in March 2020, experienced a decline from the tenth to the fourteenth week and then stabilized until the nineteenth week. In the twentieth week, progress declined again until the last week of the project. This indicates that the actual progress in the field differed from the planned progress. In the twentieth week, where the planned progress should have reached 42.53%, the actual progress in the field was only 41.85%. This discrepancy also led to cost overruns compared to the budgeted amount. Therefore, the EV method needs to be applied as an evaluation of time and cost from the decline in the twentieth week until the completion of the project.

The application of the EV method as an evaluation in the construction of the Gunung Anyar apartment must be supported by accurate input data that reflects the current on-site conditions to maximize the effectiveness of the method. It is hoped that through the implementation of this method, issues such as cost overruns and delays in project completion can be minimized in future apartment construction projects.

2.Method

After understanding the background of the research and formulating the problem, the research analysis process requires a series of steps or procedures to achieve success in accordance with the initial objectives, as depicted in Figure 2. The background is derived from issues arising in the field due to delays in project implementation and other obstacles that may lead to cost overruns. In this context, the problem to be evaluated is the construction of the Gunung Anyar Apartment. The formulation of the problem to be addressed is how the EV analysis method can evaluate a project.

As the contextual description, EV concept can assist having a proper illustration of the project. This section is classified to have several activities as follows:

- Project Baseline: The starting point that includes the original project schedule, budget, and scope.
- Planned Value (PV): The authorized budget allocated to the scheduled work. It represents the value of the work that should have been completed up to a specific point in time.
- Earned Value (EV): The value of the work actually performed or completed up to the current date. It is measured in the same terms as the Planned Value.
- Actual Cost (AC): The total cost incurred for the actual work performed up to the current date.
- Cost Performance Index (CPI): A ratio of Earned Value to Actual Cost, indicating cost efficiency.
- Schedule Performance Index (SPI): A ratio of Earned Value to Planned Value, indicating schedule efficiency.
- Variance Analysis: Examination of the differences between Planned Value, Earned Value, and Actual Cost to assess project performance.
- Forecasting: Predicting future project performance based on current trends and indices.
- EAC (Estimate at Completion): A projection of the total cost of the project based on performance to date.
- BAC (Budget at Completion): The total budget allocated for the entire project.
- To-Complete Performance Index (TCPI): A measure of the required efficiency for the remaining work to achieve specific project goals.

2.1. Cost (Cost Variance and Cost Performance Index)

The earned value method is derived from equation 1.

$$\text{Earned Value} = \text{Completion} \times \text{Budget} \tag{1}$$

After identifying cost overruns from the data obtained, which involves the planned budget data and the weekly actual cost report, cost variance (CV) and cost performance index (CPI) are calculated to evaluate the cost aspect. CV and CPI values can be calculated using equations (2) and (3).

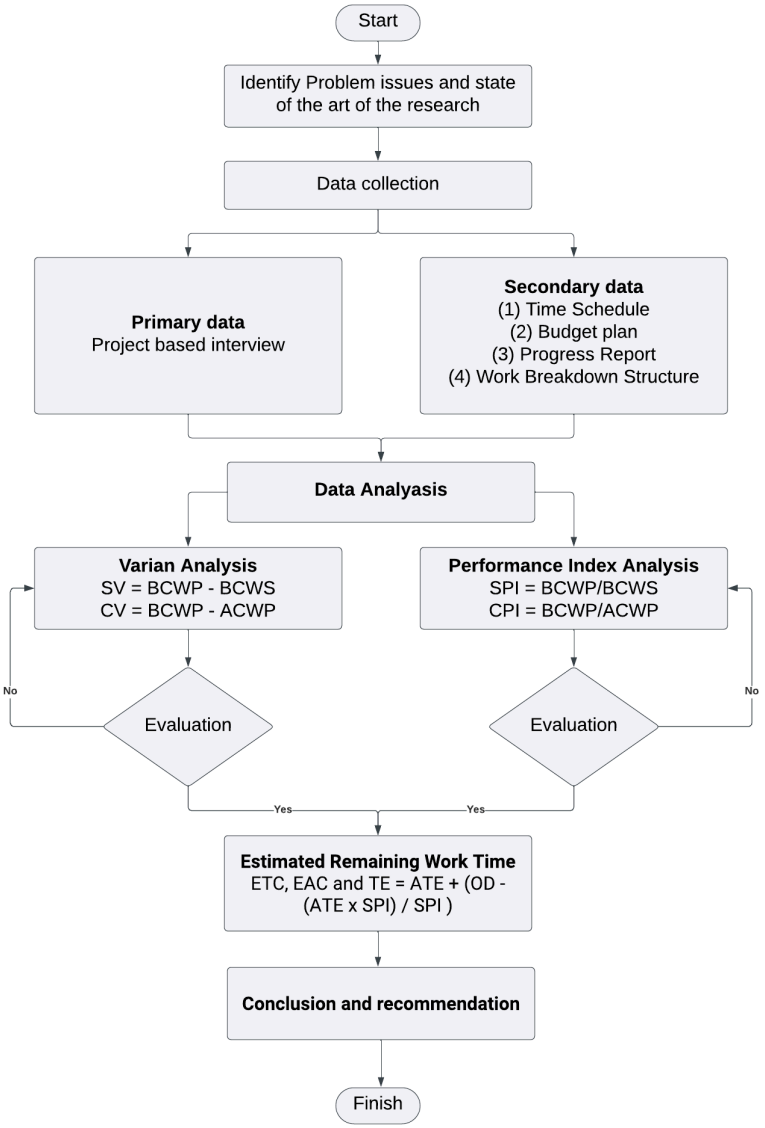

Figure 1. Illustrative chart of how the EV process conducted under case study of Gunung Anyar Apartment

(1) Cost Variance (CV) Analysis using EV.
CV is calculated as the difference between BCWP and ACWP. Cost Variance (CV) represents the difference between the earned value in cost units and the actual cost incurred for a given task. The CV value is determined by equation 2.

$$CV = BCWP – ACWP \quad (2)$$

(2) The Cost Performance Index (CPI)
CPI is determined by calculating the ratio of the Budgeted Cost of Work Performed (BCWP) to the Budgeted Cost of Work Scheduled (BCWS). The CPI is the result of dividing the value of completed work by the total cost incurred during the project. If the CPI is less than 1, it signifies poor project performance, indicating that the costs incurred exceed the value of the completed

work. CPI is employed to assess the efficiency of project performance. The value of the Cost Performance Index is derived from Equation 3:

$$CPI = BCWP / ACWP \quad (3)$$

Where: CPI is the cost performance index, BCWP is the budgeted cost of work performed and ACWP is the actual cost of work performed. This formula enables project managers to evaluate and monitor the financial efficiency of the project. A CPI greater than 1 indicates favorable performance, where the value of the work accomplished exceeds the costs incurred. Conversely, a CPI less than 1 signals potential financial challenges, as the costs are surpassing the value of the work completed. The CPI serves as a valuable metric for assessing project efficiency and guiding decision-making to ensure optimal financial management throughout the project's lifecycle.

2.2. Time (Schedule Variance and Schedule Performance Index)

Schedule Variance (SV) is derived from the difference between BCWP (Budgeted Cost of Work Performed) and ACWP (Actual Cost of Work Performed). Schedule Variance, also known as cost variance, represents the difference between the earned value in cost terms and the budgeted cost. The formula for Schedule Variance (SV) is obtained as follows:

$$SV = BCWP – BCWS \quad (4)$$

Schedule Performance Index (SPI) is determined by the ratio of BCWP to ACWP. SPI reflects the ratio of the earned value of work performed to the budgeted cost based on the specified time. If the SPI result is less than 1, it indicates that the project's performance is not meeting the planned target. SPI is also utilized to assess the overall performance of a project. The Schedule Performance Index is calculated using the equation:

$$SPI = BCWP / BCWS \quad (5)$$

The ETC represents the estimated cost for the remaining work, assuming that expenditures will align with the budget, and performance will remain stable until the project completion. ETC is a forecast of the remaining costs in a project and can be viewed from different perspectives, including:

The estimated cost incurred to complete a task based on the initial budget, regardless of the reported earned value. The assumption that the project's performance will neither degrade nor progress faster during implementation. The estimation in a project depends on the cost estimate used and the performance obtained. The ETC value is divided into two categories: for progress <50% and progress >50%, derived from equations 6 and 7.

$$ETC=\text{Total Budget}-BCWP \quad (6)$$

$$ETC=(\text{Total Budget}-BCWP)/CPI \quad (7)$$

The EAC is the estimated value of the total cost expended until the project is completed and can be determined by assessing project conditions. The Estimate at Complete (EAC) is an estimate of the total cost expended until project completion by summing the actual costs for completed project work and the value of the Estimate to Complete (ETC). The Estimate to Complete is obtained through four conditions as follows:

1. If CPI is expected to remain the same until the project is finished.

$$EAC=\text{Total Budget}/CPI \quad (8)$$

2. If future work will be completed as planned.

$$EAC=ACWP+Total\ Budget-BCWP \quad (9)$$

3. If the initial plan is invalid.

$$EAC=ACWP+\ Bottomup\ ETC \quad (10)$$

4. If CPI and SPI affect the remaining work.

$$EAC=ACWP+((Total\ Budget-BCWP)/(CPIxSPI) \quad (11)$$

TE provides an estimation of the project work time, with a tendency for performance to remain constant until project completion. Through various data analyses, project performance aligned with the research objectives is obtained, allowing for conclusive research findings for the Gunung Anyar apartment project. Time Estimate (TE) is the estimated time for project work completion. The Time Estimate tends to predict that project performance will remain constant until project completion. To determine the Time Estimate result, Equation 12 is employed:

$$TE=ATE+(OD-(ATExSPI)/SPI) \quad (12)$$

In the application of the earned value method on an "S" curve graph, performance results in the form of cost variance and schedule variance will be obtained, indicating negative or positive outcomes, each with specific implications as outlined in Table 1 and Table 2.

Table 1. Earned Value Variance Values

Schedule Variance (SV)	Cost Variance (CV)	Description
Positive	Positive	Work completed faster than the specified schedule, and costs incurred are less than the budget.
Zero	Positive	Work completed according to the schedule, with costs incurred not exceeding the budget.
Positive	Zero	Work not delayed from the specified schedule, and costs incurred are equivalent to the budget.
Zero	Zero	Work completed as scheduled, and costs incurred align with the budget.
Negative	Negative	Project delayed, and costs incurred exceed the budget.
Zero	Negative	Project completes as scheduled, but costs incurred exceed the budget.
Negative	Zero	Project completes late, but actual costs incurred align with the budget.
Positive	Negative	Work completed faster than the schedule, but costs incurred exceed the budget.

These variance values in Table 1 provide insights into the performance of a project in terms of schedule and cost. Positive values generally indicate favorable conditions, while negative values may suggest potential issues or inefficiencies. Understanding these variances helps project managers assess

the project's status, make informed decisions, and take corrective actions to ensure successful project completion within budget and schedule constraints.

Table 2. Earned Value Performance Index Values

Index	Value	Description
CPI	> 1	Actual costs incurred are less than the earned value performance obtained.
CPI	< 1	Actual costs incurred are greater than the earned value performance obtained.
CPI	= 1	Actual costs incurred are proportionate to the earned value performance.
SPI	> 1	Project performance is ahead of the specified schedule.
SPI	< 1	Project performance is delayed compared to the specified schedule.
SPI	= 1	Project performance aligns with the specified schedule.

CPI (Cost Performance Index):

- CPI > 1: Indicates that the actual costs incurred are less than the value of the earned value performance. This suggests cost efficiency, where expenditures are below what is expected based on the work performed.
- CPI < 1: Suggests that the actual costs incurred are greater than the earned value performance. This implies a cost overrun, where expenditure exceeds what is expected based on the work performed.
- CPI = 1: Indicates that the actual costs incurred are proportionate to the earned value performance. Expenditures align closely with the planned budget.

SPI (Schedule Performance Index):

- SPI > 1: Indicates that project performance is ahead of the specified schedule. The work is progressing faster than planned.
- SPI < 1: Suggests that project performance is delayed compared to the specified schedule. The work is progressing slower than planned.
- SPI = 1: Indicates that project performance aligns with the specified schedule. The work is progressing exactly as planned.

These performance indices, CPI and SPI, provide insights into the cost and schedule efficiency of a project. Values above 1 indicate favorable conditions, while values below 1 indicate potential issues or inefficiencies. A value of 1 signifies that the project is exactly on track according to the plan. Monitoring these indices allows project managers to assess and adjust the project's trajectory, ensuring it stays within budget and on schedule.

3. Results and Discussion

The review was conducted over 18 weeks for the Gunung Anyar apartment construction project, spanning from July 27 to December 7. This period encompasses the weeks showing a decline in progress, specifically from week 20 to week 38. The analysis focuses on the first month's report, covering weeks 20 to 23, which corresponds to the period from July 27 to August 23.

A. Discussion of First Month's Calculation (July 27 – August 23)

In the process of evaluating project performance, various metrics are calculated to assess both planned and actual progress. One crucial metric is the Budgeted Cost Of Work Schedule (BCWS), also known as the Planned Value. For Week 20, the planned progress was set at 4%, with a cumulative BCWS for Week 19 at Rp. 7,526,223,538 and a total budget of Rp. 19,533,411,725. The BCWS for Week 20 is determined by multiplying the planned progress percentage by the total budget, resulting in Rp. 781,336,469. Cumulative BCWS is then obtained by adding the BCWS for Week 20 to the cumulative BCWS for Week 19, yielding Rp. 8,307,560,007. This BCWS calculation is extended for subsequent weeks, and the cumulative values are illustrated having the increased behavior.

Similarly, the Budgeted Cost Of Work Performed (BCWP), or Earned Value, is computed. For Week 20, the BCWP is determined by multiplying the percentage weight of completed work (1.69%) by the total budget, resulting in Rp. 330,114,658.2. Cumulative BCWP is obtained by adding the BCWP for Week 20 to the cumulative BCWP for Week 19, yielding Rp. 8,164,966,101. This BCWP calculation is based on the percentage weight of completed work for Week 20 and the cumulative BCWP for Week 19.

The Actual Cost Work Performed (ACWP) for Week 20 is given as Rp. 8,443,453,000. These calculations provide valuable insights into project cost and schedule performance, enabling effective monitoring and decision-making throughout the project lifecycle.

Table 3. Percentage Cost and Time Indicators Variance and Performance Index Analysis

Earned Value Plan	42,53 %
Actual	41,85%
BCWS	Rp.10.770.723.225
BCWP	Rp.10.008.920.168
ACWP	Rp.10.347.636.000
SV	Rp.453.175.152
CV	Rp.338.715.832,1
SPI	0,99
CPI	0,97

Table 4. Earned Value Analysis Results

Percentage	Cost and Time Indicators	Variance and Performance Index Analysis
68.90%	65.07%	Rp. 11,427,045,859
81.66%	82.27%	Rp. 15,950,984,015
94.21%	93.52%	Rp. 18,402,427,186
- %	100%	Rp. 19,533,411,725

The table represents the Earned Value analysis, comparing planned, actual, and earned values along with various indicators such as Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI), and Cost Performance Index (CPI). The values indicate that the project is slightly behind schedule (SPI < 1) and has exceeded the planned budget (CPI < 1). The negative SV and CV values

further emphasize the delays and cost overruns in the project. In the assessment of the project's anticipated conclusion, key calculations are performed to project future costs and time requirements.

The Estimate To Complete (ETC) is determined by subtracting the cumulative Budgeted Cost Of Work Performed (BCWP) up to Week 20 from the total budget and then dividing by the Cost Performance Index (CPI). The formula yields ETC = ((Rp. 19,533,411,725 - Rp. 8,164,966,101) / 0.97), resulting in Rp. 11,756,195,325.

The Estimate At Complete (EAC) is computed by dividing the total budget by the Cost Performance Index (CPI). The formula is EAC = (Rp. 19,533,411,725 / 0.97), resulting in Rp. 20,199,648,325. Additionally, the Time Estimate (TE) is calculated by adding the Actual Time Estimate (ATE) to the product of the Original Duration (OD) minus the product of ATE and Schedule Performance Index (SPI), divided by SPI. The formula yields TE = 161 + ((259 - (161 x 0.9828)) / 0.9828), resulting in 264 days.

In the first-month review report (July 27 - August 23), the project is estimated to experience a delay of 5 days from the initial plan of 259 days. The calculations for the second month onward are adjusted based on the first month calculations. These analyses are applied to subsequent months, and the results can be observed in Table 3 and Table 4.

The table presents the results of Earned Value analysis at different project completion percentages. The indicators include the planned and actual percentages, as well as metrics such as Budgeted Cost Of Work Schedule (BCWS), Budgeted Cost Of Work Performed (BCWP), Actual Cost Work Performed (ACWP), Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI), and Cost Performance Index (CPI). The analysis reveals variances and indices that provide insights into the project's cost and schedule performance at various stages of completion.

In fact, it is evident that the project, initially planned for 37 weeks, is still at a completion percentage of 98.36%. This indicates a need for additional time to complete the remaining work. Upon applying the Earned Value method, the Earned Value performance of Rp. 19,533,411,725 is found to be equal to the total budget, aligning with the extended timeline reaching Week 38. In Week 37, as per the original plan, the Schedule Variance is -328,161,317, and the Cost Variance is -2,342,446,592. The Earned Value performance indices, namely Schedule Performance Index (0.9832) and Cost Performance Index (0.8913), provide insights into the project's schedule and cost efficiency.

Applying the Earned Value method in the final estimation analysis for the extended week reveals a projected total cost of Rp. 21,863,495,000, assuming the Cost Performance Index remains constant for the remaining project duration. This projected cost aligns with the actual costs reported weekly by the Gunung Anyar apartment project. The analysis of the projected end date indicates a 38-week timeline, and a detailed calculation using the Earned Value method at the end of the planned week reveals a specific delay of 4 days from the initially scheduled project timeline.

4. Conclusion

Based on the project management evaluation using the Earned Value method, the following conclusions can be drawn:

1. The project is experiencing a delay, transitioning from the originally planned Week 37 to Week 38. This is evident from the negative schedule variance and a schedule performance index (SPI) less than 1.
2. The negative cost variance and a cost performance index (CPI) less than 1 indicate that the project is incurring cost overruns compared to the initial plan of Rp. 19,533,411,725, reaching

Rp. 21,863,495,000.

3. The Earned Value method evaluates the performance of the Gunung Anyar Apartment Construction project and estimates the final cost in Week 38 to be equal to the Actual Cost Work Performed, which is Rp. 21,863,495,000. Additionally, the project is delayed by 4 days, extending into Week 38.
4. The application of the Earned Value evaluation is recommended at Week 10 when the project is still in progress, and a decline in progress is observed, specifically a -0.09% decrease. This early evaluation allows for proactive measures to be taken to address potential issues and deviations from the project plan.

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