ANALYSIS OF PROJECT ENFORCEMENT DELAYS WITH THE EARNED VALUE METHOD
(Case study: Office of Bahtera Elang Perak Indonesia Surabaya)

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Abstract

The construction of the Bahtera Elang Perak Indonesia (BEPI) Office is one of the ongoing projects in Surabaya City consisting of 8 floors with an area of 1,081 m² and a contract value of Rp. 13,908,226,157.00. The Bahtera Elang Perak Indonesia office construction project is planned to last for 43 weeks. In reality, when the piling work is in progress, there are several changes so that there is a need for rescheduling or re-schedulling. The length of implementation time became 54 weeks. The current condition of the progress of the construction of the Bahtera Elang Perak Indonesia Surabaya office is in week 37 at 35.67% while the planned progress is 43.619% so that there is a difference of -7.948%. In order to address this issue, an evaluation of the project's cost and time efficiency during implementation is conducted utilizing the Earned Value Method. This strategy seeks to assess the project's performance in terms of both cost and time. The analysis conducted in week 41 revealed that the performance of the project, in terms of cost, was below expectations with a CPI value of 0.945, indicating that the actual costs exceeded the budgeted costs. Additionally, the CV value of Rp. -381,606.94 further confirmed this negative deviation. In terms of time, the project also experienced delays, as indicated by an SPI value of 0.758, which is less than 1. The SV value of Rp. -2,082,524,745 further highlighted this delay, indicating that the completed work packages were fewer than planned.

Keywords: Cost Performance, Schedule Performance, Earned Value

1. INTRODUCTION

Construction management is the planning, scheduling and controlling of projects to achieve project objectives without any deviation. Effective management of a program during the construction project operation cycle requires a good cost organization and control system. Management must compare the cost, time, and performance of the program against the cost budget plan, time plan, and performance in each activity. If not effectively managed, the activities inside the project will give rise to a range of adverse consequences, finally resulting in the inability to attain the targeted goals and objectives (Bartholomeus, 2022).

The construction of Bahtera Elang Perak Indonesia (BEPI) Office is one of the ongoing projects in Surabaya City, precisely on Jl. Simpang Darmo Permai Selatan I no 38 which consists of 8 floors with an area of 1,081 m² and a contract value of Rp. 13,908,226,157.00. The project is planned to last for 43 (forty-three) weeks, starting on June 19, 2023 until April 14, 2024. Foundation works which include pile drilling, strauss,

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piling, and pile testing will run within 5 weeks. The earthworks and lower structural concrete works will run for 20 weeks.

In reality, when the piling work was in progress, there were several changes that occurred in the field, including the addition of pile points from the planner, changes in drawings, additional pile drilling, and the addition and review of re-drive work due to the request of the planner. These things caused a significant delay in this project so that it was necessary to reschedule or re-scheduling the reference schedule that had been planned at the beginning of the project. Rescheduling or re-scheduling of the initial schedule carried out on this project has an impact on increasing the duration of the work, causing the project completion target to be delayed from the time it should be. The project which was planned to be completed in 43 weeks was postponed by 11 weeks where the total completion plan became 54 weeks. The new target completion plan for this project is on June 30, 2024. In week 32, the project realization progress of 24.505% has decreased from week 31 by -0.225% while the total actual cost or that has been incurred during the work in week 31 is Rp. 3,191,740,254.

The current condition of the BEPI Surabaya Office Construction progress is in week 37 with a cumulative progress of 35.67% while the planned cumulative progress or stated on the S curve is 43.619%. From these figures there is a considerable difference of -7.948%. As a consequence, the project encountered a significant deviation from the original schedule. Cost and time management procedures are necessary for every construction project, irrespective of the execution conditions, in order to accomplish the project's goals of success. The success of a project hinges on the capacity of the parties involved to finish the project within the designated timeframe and budget. The control process must be done properly so that any deviations that occur can be identified and evaluated properly. Project performance must be known before taking the necessary actions to control a project (Asmoro et al., 2024)

The Earned Value method is a technique used to assess project performance. This approach integrates the components of expense, timeline, and task execution. By quantifying the progress of a task and evaluating it in relation to the allocated budget (Proboretno et al., 2024). The Earned Value technique analyses project performance by examining cost variance analysis, cost performance index, time analysis (schedule variance), and time performance (schedule performance index). The calculations are derived from the planned value, result value, and actual cost (Khairunnisa et al., 2020).

Based on the explanation above, the progress that has been achieved there is a considerable difference between the plan and the realization of the project, therefore the BEPI Surabaya Office Construction project can be controlled. Control is implemented with the earned value methodology. This research aims to analyze project performance based on cost variance, cost performance index, schedule variance and schedule performance index.

2. LITERATURE REVIEW
2.1. Project Performance and Control

Project performance refers to the evaluation of how well a project is progressing by comparing the actual outcomes of the work to the anticipated outcomes outlined in the contractual agreement between the project owner and the contractor responsible for

implementation. An example when the project activity report occurs faster than expected but the expenditure of funds that has been made turns out to be over budget. If control measures are not taken immediately, the project may not be completed in its entirety due to lack of funds (Zaki et al., 2021).

Control is a methodical procedure that involves establishing criteria based on planned objectives, creating information systems, comparing the actual implementation with the established criteria, analysing any discrepancies between the implementation and the criteria, and subsequently taking corrective measures to ensure the efficient and effective utilization of resources in order to achieve the desired objectives. Project activities are supervised, scrutinized, corrected, and guided to achieve objectives (Arsjad et al., 2020).

2.2. Earned Value Concept

In project management, earned value, alternatively referred to as net present value, is a tool utilized to integrate time and costs in order to consider three distinct facets: the percentage of completed projects, the utilization rate (comprised of budgeted and actual costs), and the value derived from previously incurred costs, typically earned value (Hamrozi & Adistana, 2022). Control is a methodical procedure for establishing criteria based on planning goals, developing information systems, comparing implementation to criteria, analyzing potential discrepancies between implementation and criteria, and subsequently implementing appropriate corrective measures to ensure efficient and effective utilization of resources in order to achieve objectives. Project activities are closely monitored, examined, rectified, and directed in order to accomplish objectives (Satrio, 2020).

There are 2 types of project control that are commonly carried out, namely project cost control, namely project cost control is needed so that the project can be carried out properly and does not exceed the planned budget and project time control, and project time control, namely scheduling includes labor, materials, equipment, finance, and time which, if done correctly, can avoid problems such as delays, higher costs, and disagreements in construction projects.

a. Earned Value Concept Indicator Analysis
a) Planned Value (PV) or Budgeted Cost of Work Schedule (BCWS)
   The PV calculation is derived from the aggregation of the predetermined cost budget for the specified time period.
b) Earned Value (EV) or Budget Cost of Work Performed (BCWP)
   The calculation of expected value (EV) is derived from the total number of completed jobs.
c) Actual Cost (AC) or Actual Cost of Work Performed (ACWP)
   AC computations are cumulative until the end of the performance calculation period or until a set threshold of expenses is reached during a specific timeframe.

b. Cost and Time Variance Analysis
a) Cost Variance (CV)

The difference between the actual costs incurred during the project and the value obtained after the work package is completed.

CV = EV-AC
    CV = 0 : costs according to the plan budget
    CV > 0 : smaller costs/savings
    CV < 0 : greater cost / waste

b)   Schedule Variance (SV)
Used to calculate the deviation between Present Value (PV) and Earned Value (EV).

SV = EV-PV
SV = 0 : project on time
SV > 0 : faster project
SV < 0 : late project

The resulting Variance value is used as a project performance measurement tool with the provisions in Table 1.

Table 1. Integrated analysis of variance

Schedule Variance (SV)	Cost Variance (CV)	DESCRIPTION
Positive	Positive	Work accomplished ahead of schedule at a cost less than budgeted
Zero	Positive	Work accomplished on schedule at a cost lower than budget
Positive	Zero	Zero Work accomplished ahead of schedule at cost within budget
Zero	Zero	Work carried out according to schedule and budget
Negative	Negative	Work completed late and costing more than budgeted
Zero	Negative	Work accomplished on schedule at a higher cost than budgeted
Negative	Zero	Work completed late and costing within budget
Positive	Negative	Work completed ahead of schedule at a higher cost than budgeted

Source : Satrio, 2020

c.   Performance Index Analysis
a)   Cost Performance Index (CPI)
The cost efficiency factor that has been incurred is obtained. This CPI value indicates how heavily the value gained compares to the costs incurred.

CPI = EV/AC
CPI = 1 : cost as planned
CPI > 1 : more cost-effective
CPI < 1 : more wasteful costs

The CPI value indicates the relative weight of the obtained value in relation to the incurred costs. A CPI score below 1 implies subpar cost performance due to higher actual expenses (ACWP) compared to the earned value (BCWP), or the presence of inefficiencies and waste.

b)   Schedule Performance Index (SPI)
It is a factor of performance efficiency in completing work. The SPI value shows how much work can be completed when compared to the overall project.

SPI = EV/PV………………………………………………………………….(4)
SPI = 1 : projects run on time
SPI > 1 : projects run faster
SPI < 1 : project was delayed

The SPI value indicates the amount of work completed in comparison to the overall project. If the SPI value falls below 1, it indicates that the work performance is not meeting the set targets.

2.3. Previous Research

One of the previous studies that used the earned value method was the Cost and Time Analysis of Apartment Projects with the Earned Value Concept Method. The research was conducted on an apartment building with a total of 31 floors and a budget of Rp. 328,846,028,120, the results obtained were that the cost performance of the project was not in accordance with the plan because the CPI value was 0.861 or CPI < 1 while the project's time performance experienced delays in the implementation of work from the planned schedule with a SPI value < 1 (Castollani & Puro, 2020).

Another study that uses this method is the Cost and Time Analysis of the PTFI Pier Construction Project with the Earned Method. The results obtained in this study are cost performance at week 23 on the PTFI dock construction project of 1.030 or CPI> 1 and a CV value of Rp. 9,368,877,120 this indicates that the costs that have been incurred are smaller than the budgeted plan while the time performance is faster than the schedule plan with a large SPI value of 1.017 or SPI> 1 and SV is positive (Bima Adnanta, Wateno Oetomo, 2022).

The study "Analysis of Implementation Delays Using the Earned Value Method (On the Purwosari-Sekarmojo Road Works, Pasuruan District)" employs the Earned Value Method to examine the project's cost and time performance. The results obtained from the study are cost performance has a value of 1.14 or CPI> 1 and time performance has a value of 0.587 or SPI < 1 (Balido et al., 2024).

3. RESEARCH METHODS

The research was conducted at the BEPI Office Development located at Simpang Darmo Permai Selatan I no.38, Surabaya City, data collection was obtained from personal documentation in the form of photos of project progress and from the implementing contractor in the form of Budget Plan Cost (RAB), Time Schedule, weekly project report, actual cost report. The stages of research analysis are the stages in the earned value method carried out by researchers sequentially during the research. These stages are as follows:

a. Analysis of Earned Value Concept Indicators
    a) Planned Value (PV) or Budgeted Cost of Work Schedule (BCWS)
    b) Earned Value (EV) or Budget Cost of Work Performed (BCWP)
    c) Actual Cost (AC) or Actual Cost of Work Performed (ACWP)

b. Cost and Time Variance Analysis
    a) Cost Variance (CV)
    b) Schedule Variance (SV)

c. Analysis of Performance Index
    a) Cost Performance Index (CPI)
    b) Schedule Performance Index (SPI)

4. RESULTS AND DISCUSSION

The project implementation was planned for 54 weeks, the delay in project implementation occurred starting in week 32 with the total actual cost in week 31 of Rp. 3,191,740,254. while the research was carried out in weeks 38-41, namely March 04, 2024 - March 31, 2024. A Planned Value (PV) or Budgeted Cost of Work Schedule (BCWS), Earned Value (EV) or Budgeted Cost of Work Performance (BCWP), and Actual Cost (AC) or Actual Cost for Work Performed (ACWP) are the results of applying the Earned Value method to the BEPI Surabaya office construction project.

4.1. Analysis of Earned Value Concept Indicators

4.1.1. Planned Value (PV) or Budgeted Cost of Work Schedule (BCWS)

The S-curve graph of project planning and realization reveals that the 41st week's work completion percentage falls short of or surpasses the plan. To calculate the PV or BCWS value at the 41st week review, we use the following formula:

PV = % weekly plan weight x plan budget
   = 3.957% x Rp. 13,908,226,157,-
   = Rp. 550,338,505,-

Table 2. Recapitulation of Planned Value (PV)

Week of	Weekly Plan Weight	PV	
		Week	Cumulative
		(Rp)	(Rp)
32	1.679	233,577,750	3,439,528,805
33	2.600	361,615,352	3,801,144,157
34	3.553	494,155,088.87	4,295,299,246
35	3.528	490,657,545	4,785,956,791
36	4.595	639,023,796	5,424,980,588
37	4.613	641,616,815	6,066,597,403
38	5.393	750,036,323	6,816,633,726
39	4.091	568,946,986	7,385,580,712
40	4.774	664,027,996	8,049,608,708
41	3.957	550,338,505	8,599,947,213

Source: Analysis Result, 2024

According to the calculations presented in Table 2, the PV or BCWS value for the 41st week is Rp. 550,338,505. The PV or BCWS value for the 41st week is Rp. 8,599,947,213, which includes the accumulation from the previous week.

4.1.2 Earned Value (EV) or Budgeted Cost for Work Performed (BCWP)

Earned Value (EV) refers to the planned cost of work that has been successfully accomplished within a specific timeframe, or the actual cost of work performed. Earned Value (EV) is derived by multiplying the percentage of progress achieved in the field by the planned budget for a specific period (BAC), which represents the project plan budget, and comparing it to the actual amount of work completed. Below is the computation of the coefficient of variation (CV) for week 41:

EV = % Realization Weight x Project Value
   = 2.650 % x Rp. 13.908.226.157,-
   = Rp. 368.567.993,-

Table 3. Recapitulation of Earned Value (EV)

Week of	Weekly Realization Weight	EV	
		Week	Cumulative
		(Rp)	(Rp)
32	1.256	174,652,864	3,408,274,549
33	1.043	145,078,218	3,553,352,768
34	1.524	211,963,106	3,765,315,874
35	2.965	412,358,576	4,177,674,450

Week of	Weekly Realization Weight	EV	
		Week	Cumulative
		(Rp)	(Rp)
36	1.890	262,916,712	4,440,591,162
37	3.742	520,514,157	4,961,105,319
38	2.902	403,595,589	5,364,700,908
39	2.503	348,128,074	5,712,828,982
40	3.135	436,025,493	6,148,854,475
41	2.650	368,567,993	6,517,422,468

Source: Analysis Result, 2024

In Table 3, it is known that the value of EV or BCWP for the 41st week is Rp. 368.567.993, - Subsequently, when combined with the previous week, the cumulative value of Earned Value (EV) or Budgeted Cost of Work Performed (BCWP) up to the 41st week amounts to Rp. 6.517.422.468.

4.1.3 Actual Cost (AC) or Actual Cost for Work Performed (ACWP)

The Actual Cost (AC) refers to the real budget allocated for the completed activity, based on the actual amount of work performed. The calculation of AC or ACWP is derived from the computation of direct expenses (Direct Cost) and indirect costs (Indirect Cost) in the Surabaya BEPI Office Development project.

Table 4. Recapitulation of Actual Cost Value (AC)

Week of	Weekly Realization Weight	AC	
		Week (Rp)	Cumulative (Rp)
32	1.256	299,174,025	3,490,914,279
33	1.043	180,854,216	3,671,768,495
34	1.524	292,789,214	3,964,557,709
35	2.965	422,016,756	4,386,574,465
36	1.890	308,172,055	4,694,746,520
37	3.742	627,273,311	5,322,019,831
38	2.902	414,327,834	5,736,347,665
39	2.503	366,400,572	6,102,748,237
40	3.135	470,238,125	6,572,986,362
41	2.650	326,043,055	6,899,029,417

Source: Analysis Result, 2024

From the table above, the value of AC or ACWP in week 41 is Rp. 32.043.055, - The value of AC or ACWP up to week 41 is Rp. 6.889.029.417, - when combined with the preceding month's total.

4.2. Cost and Time Variance Analysis

4.2.1 Cost Variance (CV)

Cost Variance (CV) assesses if the current project is still within the predetermined cost or budget limit. Below is the computation of the coefficient of variation (CV) for week 41:

$$CV = EV - AC$$
$$= Rp\ 6.517.422.468 - Rp\ 6.899.029.417$$
$$= Rp.\ -381.606.949,-$$

The CV value is Rp -381,606,949, - This implies that the CV value is less than 0 (CV < 0) or has a negative value. This indicates that the actual expenses incurred in completing the project exceed the planned budgeted costs.

Table 5. Recapitulation of Cost Variance Value (CV)

Week of	EV	AC	CV
	a	b	(a-b)
32	3,408,274,549	3,490,914,279	-82,639,730
33	3,553,352,768	3,671,768,495	-118,415,727
34	3,765,315,874	3,964,557,709	-199,241,835
35	4,177,674,450	4,386,574,465	-208,900,015
36	4,440,591,162	4,694,746,520	-254,155,358
37	4,961,105,319	5,322,019,831	-360,914,512
38	5,364,700,908	5,736,347,665	-371,646,758
Week of	**EV**	**AC**	**CV**
	a	b	(a-b)
39	5,712,828,982	6,102,748,237	-389,919,255
40	6,148,854,475	6,572,986,362	-424,131,887
41	6,517,422,468	6,899,029,417	-381,606,949

Source: Analysis Result, 2024

4.2.2 Schedule Variance (SV)

The schedule variance value for week 41 is calculated as follows:

$$SV = EV - PV$$
$$= Rp\ 6,517,422,468 - Rp\ 8,599,947,213$$
$$= Rp\ -\ 2.082.524.745$$

Based on the above calculations, the SV value is Rp 2,082,52,745. When the SV value is less than 0 (SV < 0) and is negative, it means that the project has been delayed

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from the planned schedule and that the work packages that have been implemented are less than the planned work.

Table 6. Recapitulation of Schedule Variance Value (SV)

Week of	PV	EV	SV
	a	b	(b-a)
32	3,439,528,805	3,408,274,549	-31,254,256
33	3,801,144,157	3,553,352,768	-247,791,390
34	4,295,299,246	3,765,315,874	-529,983,372
35	4,785,956,791	4,177,674,450	-608,282,341
36	5,424,980,588	4,440,591,162	-984,389,425
37	6,066,597,403	4,961,105,319	-1,105,492,084
38	6,816,633,726	5,364,700,908	-1,451,932,818
39	7,385,580,712	5,712,828,982	-1,672,751,731
40	8,049,608,708	6,148,854,475	-1,900,754,233
41	8,599,947,213	6,517,422,468	-2,082,524,745

Source: Analysis Result, 2024

4.3. Analysis of Performance Index
4.3.1 Cost Performance Index (CPI)

CPI is determined by comparing the value of finished work (EV) to the expenditures spent during the same time period (AC).

CPI = EV/ AC
    = Rp 6.517.422.468/ Rp 6.899.029.417
    = 0,945

The CPI value is less than 1 (CV < 1), namely 0.945, this suggests that the expenses incurred in the completion of the project exceed the initially planned budget.

Table 7. Recapitulation of Cost Performance Index Value (CPI)

Week of	EV	AC	CPI
	a	b	a/b
32	3,408,274,549	3,490,914,279	0.976
33	3,553,352,768	3,671,768,495	0.968
34	3,765,315,874	3,964,557,709	0.950
35	4,177,674,450	4,386,574,465	0.952
36	4,440,591,162	4,694,746,520	0.946
37	4,961,105,319	5,322,019,831	0.932
38	5,364,700,908	5,736,347,665	0.935
39	5,712,828,982	6,102,748,237	0.936
40	6,148,854,475	6,572,986,362	0.935

Week of	EV	AC	CPI
	a	b	a/b
41	6,517,422,468	6,899,029,417	0.945

Source: Analysis Result, 2024

4.3.2 Schedule Performance Index (SPI)

We use the Schedule Performance Index (SPI) as a reference to measure the performance of implementation time by comparing the EV value with the PV value.

SPI = EV / PV
 = Rp 6.517.422.468 / Rp 8.599.947.213
 = 0,758

The SPI value of less than 1 (SV < 1) of 0.758 Signifies that the project is encountering setbacks or underperforming due to its inability to meet the established work objectives.

Table 8. Recapitulation of Schedule Performance Index Value (SPI)

Week of	EV	PV	SPI
	a	b	a/b
32	3,408,274,549	3,439,528,805	0.991
33	3,553,352,768	3,801,144,157	0.935
34	3,765,315,874	4,295,299,246	0.877
35	4,177,674,450	4,785,956,791	0.873
36	4,440,591,162	5,424,980,588	0.819
37	4,961,105,319	6,066,597,403	0.818
38	5,364,700,908	6,816,633,726	0.787
39	5,712,828,982	7,385,580,712	0.774
40	6,148,854,475	8,049,608,708	0.764
41	6,517,422,468	8,599,947,213	0.758

Source: Analysis Result, 2024

4.4. Analysis of project performance
4.4.1 Analysis of project cost performance

The cost performance of the Bahtera Elang Perak Indonesia (BEPI) office construction project in week 41 demonstrates inefficient use of costs in this reporting period to finish the project or poor performance. The cost inefficiency is evident through the negative value of Rp. -381,606,949 for the Cost Variant (CV) indicator and the value of 0.945 for the Cost Performance Index (CPI) indicator, which is less than one, indicating that the contractor's cost expenditure exceeds the planned cost for that week.

Table 9. Recapitulation of CV and CPI Values

Week of	CV	CPI	Description
32	-82,639,730	0.976	Expenditures have exceeded initial expectations.
33	-118,415,727	0.968	Expenditures have exceeded initial expectations.
34	-199,241,835	0.950	Expenditures have exceeded initial expectations.
35	-208,900,015	0.952	Expenditures have exceeded initial expectations.
36	-254,155,358	0.946	Expenditures have exceeded initial expectations.
37	-360,914,512	0.932	Expenditures have exceeded initial expectations.
38	-371,646,758	0.935	Expenditures have exceeded initial expectations.
39	-389,919,255	0.936	Expenditures have exceeded initial expectations.
40	-424,131,887	0.935	Expenditures have exceeded initial expectations.
41	-381,606,949	0.945	Expenditures have exceeded initial expectations.

Source: Analysis Result, 2024

4.4.2 Analysis of project time performance

The performance of the Bahtera Elang Perak Indonesia (BEPI) office construction project in terms of time is low. This poor performance is evidenced by the Schedule Variance (SV) indicator, which has a negative value of Rp. - 2,082,52,745, and the Schedule Performance Index (SPI), which is 0.758, indicating that this work package is behind schedule.

Table 10. Recapitulation of SV and SPI Values

Week of	SV	SPI	Description
32	-31,254,256	0.991	the project was delayed
33	-247,791,390	0.935	the project was delayed
Week of	SV	SPI	Description
34	-529,983,372	0.877	the project was delayed
35	-608,282,341	0.873	the project was delayed
36	-984,389,425	0.819	the project was delayed
37	-1,105,492,084	0.818	the project was delayed

Week of	SV	SPI	Description
38	-1,451,932,818	0.787	the project was delayed
39	-1,672,751,731	0.774	the project was delayed
40	-1,900,754,233	0.764	the project was delayed
41	-2,082,524,745	0.758	the project was delayed

Source: Analysis Result, 2024

5. CONCLUSION

Based on the performance analysis that has been carried out on the 41st week of the Bahtera Elang Perak Indonesia (BEPI) office construction project, it can be concluded as follows the project's cost and time performance is unfavourable and inefficient due to the expenditure cost exceeding the planned amount (CPI < 1), namely in week 41 = 0.945 and the Cost Variant (CV) value is negative Rp. -381.606.949. And the time performance of the implementation project is unsatisfactory due to its deviation from the planned schedule, as indicated by a Schedule Performance Index (SPI) value of 0.758 < 1 and a negative Schedule Variant (SV) value of Rp. – 2.082.524.745.

Research findings suggest that implementing contractors can utilize the earned value method (EVM) as a tool to control costs and schedules. By applying EVM, contractors can identify and prevent deviations from the initial plan, ultimately avoiding cost losses and project delays. For further research on projecting estimated completion time using EVM calculations with Schedule Performance Index (SPI) values less than or greater than 1, it's necessary to study critical path activities. This will help identify areas for overcoming delays or accelerating the project.

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