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COST AND TIME PERFORMANCE ANALYSIS USING EARNED VALUE METHOD OF WHEAT SILO & PELLET SILO STRUCTURE REPAIR PROJECT PHASE 3 PT. ISM BOGASARI SURABAYA

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Abstract

The wheat silo and pellet silo structure repair project phase 3 by PT. ISM Bogasari Surabaya is an annual infrastructure maintenance and strengthening activity to support the smooth production process. For this reason, it is very important to be completed on time according to the contract in order to proceed to the next stage of repair and not experience delays that can result in cost overruns. In this study using EVM (Earned Value Method) analysis in overcoming these problems to determine the cost and time performance of implementation as the project progresses and the indicators used in the analysis include SV (Schedule Variance), CV (Cost Variance), SPI (Schedule Performance Index), CPI (Cost Performance Index), which aims to obtain the results of the calculation of ETC (Estimated To Complete) & EAC (Estimated At Complete) in the project completion cost forecast. While ETS (Estimated Temporary Schedule) and EAS (Estimated All Schedule) for project completion time forecast. Based on the results of the cost & time performance analysis carried out up to week 48, the CPI> 1 value shows that the project is experiencing savings and for time performance shows the SPI < 1 value, which means that the project is experiencing delays.

Keywords: *Cost, Earned Value Method, Scheduling, Time*

1. INTRODUCTION

Construction projects are complex activities, do not occur routinely, require significant investment of cost, time and resources, and have specification limitations. The project aims to achieve the goals of the stakeholders. However, often in the implementation process, there are constraints that result in failure to achieve the expected goals together (Marleno et al., 2018). Building something involves a juggling act: keeping costs down, finishing on time, and delivering high quality. The first step, planning, is crucial. It sets the blueprint for a smooth project and timely completion. Construction is like a chain reaction. Each step, from initial concept to detailed planning, influences the next. Careful cost control throughout the project is essential for staying within budget (Pabalik et al., 2018).

In the activities of a project, there will be many problems such as excessive use of materials, unskilled labor and project completion time that is not on time, causing cost overruns that are not in accordance with planning (Nurkholis & Abduh, 2022). Cost and time control is part of overall construction project management. In addition to the assessment of the quality aspect, the performance of a project can also be assessed from the aspects of cost and time (Salsabila et al., 2022). The costs that have been incurred and

the time used to complete a job must be measured on an ongoing basis for deviations from the plan. The existence of significant cost and time deviations provides an indication of poor project management. In addition, time is very important in project implementation. With time, it can be determined when a job ends. In fact, it can also be known whether a job is wasteful or efficient if it cannot be managed properly. At the project planning stage, it is necessary to estimate the duration of the project implementation time (Utomo et al., 2022). The reality in the field shows that the completion time of a project varies, as a result the estimated completion time of a project cannot be ensured to be kept (Wahyu, 2017).

The level of accuracy of the estimated project completion time is determined by the level of accuracy of the estimated duration of each job in the project. In addition to the accuracy of the time estimate, the confirmation of the relationship between the activities of a project is also necessary for the planning of a project. To estimate time and cost in a project, optimization is required (Arifin et al., 2023; Asmoro et al., 2023; Bonny et al., 2022). In running a project, it is very rare to find a project that runs exactly as specified. Generally, there are delays from what was planned, both time and work progress, but there are also projects that have accelerated from the original planned schedule (Oetomo et al., 2017).

To improve effectiveness in monitoring and controlling project activities, the Earned Value Analysis method can be applied (Ariana & Lestari, 2023). This method was developed to make estimates or projections of the future state of the project. The problem in this study is how to evaluate construction projects by applying Earned Value Analysis and calculating how much the amount of direct and indirect costs that have been incurred is more than the predetermined budget and how much delay / progress is needed to complete the construction project, if conditions are still like when reporting evaluation and control is the responsibility of a project manager. In a small project, the control process can be done directly (Febriantoro et al., 2022). But for larger scale projects the control is done indirectly (Irniawan et al., 2024). Therefore, in the process of project evaluation and control, a single information system is needed that can assess the progress and performance of the project (Putra et al., 2024).

The results of using the Earned Value method can be calculated various factors that show the progress and performance of project implementation such as cost variance or Cost Variance (CV), time variance or Schedule Variance (SV), work productivity index (CPI), time productivity index (SPI), project completion cost forecast (EAC), and project completion schedule forecast (ETC) (Farhan et al., 2021). Which will certainly greatly assist contractor performance in managing work performance, The results of the project performance evaluation obtained can be used as an Early Warning if there is poor performance in project completion so that management policies and changes in implementation methods can be made so that cost overruns and delays in project completion can be prevented (Aditama & Witjaksana, 2021).

This research will use the Earned Value Analysis method in evaluating time performance and cost performance, for which 3 (three) indicators are used, namely, ACWP (actual cost of work performed), BCWP (budgeted cost of work performed), and BCWS (bugeted cost of scheduled) (Indriani et al., 2022). ACWP is the actual cost of the work that has been carried out. This cost is obtained from project accounting or financial

data at the reporting date (e.g. end of month), which is a record of all actual cost expenditures from work packages or accounting codes including overhead calculations and others. So, ACWP is the actual amount of expenditure or funds used to carry out work in a certain period of time (Widiasanti et al., 2019).

PT Indofood Sukses Makmur Tbk. Bogasari Surabaya Division began operations on July 10, 1972, located at Jl. Nilam Timur No. 16 Tanjung Perak, Surabaya. Occupying an area of ± 14 Ha. With a milling capacity of 5,900 tons of wheat / day and a total flour production of 1.6 million tons per year. In the procurement and storage of raw materials in the form of wheat grain before being processed into flour, it needs to be stored in a place called silo, and the silo owned by Bogasari is a concrete silo. Silo owned by Bogasari is divided into 2 types, namely wheat silo to store wheat and pellet silo to store pellets, which is the remaining processed wheat skin that has been wasted which is usually used for animal feed mixture. In Bogasari there are 4 complexes, namely old pellet silos totaling 18 pieces with a height of 42 m, new pellet silos totaling 24 pieces with a height of 40 m, old wheat silos totaling 36 pieces with a height of 50 m, and new wheat silos totaling 48 pieces with a height of 36.95m. This Silo building is needed for the continuity of production, therefore maintenance of this building is carried out periodically every 20 years.

In the work of the Wheat Silo & Pellet Silo Phase 3 Structure Repair Project, there are 24 silos being worked on which absorbs a budget of Rp. 28,011,000,000 (Twenty Eight Billion Eleven Million Rupiah) which must be completed within an estimated time of 455 calendar days. During the work process of this silo repair project, bulk production loading and unloading activities continue to run, this results in increasingly complex and complicated construction projects, as well as weather factors when it rains which are always accompanied by strong winds due to the location around the seaside, which often hinders work at heights using gondolas & access into silos which are only manholes complicating the installation of supporting equipment in the work, so proper project management is needed so that the project does not exceed the specified time limit (Ervianto, 2023).

Based on the background description above, the objective problem of this research is to analyze cost and time performance with the Earned Value method with indicators of Cost Variance (CV), Schedule Variance (SV), Schedule Performance Index (SPI), Cost Performance Index (CPI). As well as analyzing the estimated remaining cost of the Estimate Temporary Schedule (ETS) project & the final time of the Estimate All Schedule (EAS) project (Husein, 2011).

2. RESEARCH METHODS

2.1. Research Subjects

Cost and time performance analysis using the Earned Value method on construction projects (Kamandang, 2022).

2.2. Research Objective

In this study, the object of research on the Wheat Silo & Pellet Silo Structure Repair Project Phase 3 PT. ISM Bogasari Surabaya.

2.3. Research Location

This research will be conducted on the Wheat Silo & Pellet Silo Phase 3 Structure Repair Project of PT ISM Bogasari Flour Mill Surabaya, located at Jl. Nilam Timur No. 16 Tanjung Perak Surabaya. which was carried out in February 2024.

2.4. Data Collection Procedure

In the research conducted on the Wheat Silo & Pellet Silo Phase 3 Structure Repair Project of PT ISM Bogasari Flour Mill Surabaya, data collection as research material was obtained from the implementing contractor. The types of data collected are secondary data types and literature studies, including:

a. Project implementation schedule (Time Schedule)
   a) S curve (Master schedule)
   b) Actual S curve of the project
b. Cost Budget Plan (RAB)
c. Project Weekly Report
d. Actual Cost

2.5. Data Analysis Technique

a. Calculating the value of AC (Actual Cost), PV (Planned Value), EV (Earned Value)

The ACWP value is obtained from direct and indirect costs incurred in project implementation. BCWS is calculated from the weight of the work plan against the cost budget plan. BCWP is calculated from the actual weight of the work against the cost budget plan.

AC = direct cost + indirect cost
PV = % plan weight x contract value
EV = % actual weight x contract value

The study forms are S AC graph, S EV graph and S PV graph.

b. Calculation Based on Cost Aspects

Calculating the value CV (Cost Variance), CPI (Cost Performance Index), ETC (Estimate to Complete), EAC (Estimate at Complete).

CV = EV – AC and CPI = EV / AC
ETC= (BAC – EV) / CPI dan EAC and AC + ETC

c. Calculation Based on Time Aspect

Calculating the value SV (Schedule Variance), SPI (Schedule Performance Index), TE (Time Estimate).

SPI = EV /PV dan SV = EV – PV
ETS = Remaining Time / SPI and EAS = Finish time + ETS

3. RESULTS AND DISCUSSION

3.1. Research Results

3.1.1. Project Overview

The project data is as follows:

Project Name	: Wheat Silo & Pellet Silo Structure Repair Project Phase 3
Implementing Agency	: PT ISM Bogasari Surabaya
Location	: Jl. Nilam Timur No. 16 Tanjung Perak, Surabaya
Contract Value	: RP 28,011,000,000
Project Duration	: 65 weeks or 455 days



Source: www.bogasari.com

Figure 1. PT ISM Bogasari Flour Mill Surabaya

3.1.2. Project Data

The data that has been obtained for this research include:

a. Cost Budget Plan (RAB)

RAB is the cost allocated to each item of work. RAB is contained in the contract between the owner and the implementing contractor, in the contract there is also an analysis of unit prices, a list of wages and material prices. RAB data is used in the calculation of planned value and earned value.

Table 1. Cost Budget Plan

No.	Uraian Pekerjaan	Jumlah Harga
A	**Preparation & Administrasi**	
I	PREPARATION & ADMINISTRATION	
A	MOBILIZATION & DEMOBILAZATION	Rp 900.000.000
B	DIREKSI KIT	Rp 149.402.290
C	TEMPORARY EQUIPMENT	Rp 400.000.000
D	ADMINISTRATION & REPORTING	Rp 2.500.000.000
E	ASURANSI	Rp 50.000.000
F	KESELAMATAN KERJA	Rp 1.380.000.000
B	**Wheat Silo Lama (A)**	
I	PREPARATION WORK	
A	SILO OUTSIDE	Rp 180.000.000
B	SILO INSIDE	Rp 630.000.000
C	SILO ROOF	Rp 150.000.000
II	REPAIR WORK	
A	SILO OUTSIDE	Rp 2.456.910.000
B	SILO INSIDE	Rp 3.888.030.000
C	SILO ROOF	Rp 1.034.052.000
C	**Wheat Silo Baru (B)**	
I	PREPARATION WORK	
A	SILO OUTSIDE	Rp 180.000.000
B	SILO INSIDE	Rp 630.000.000
II	REPAIR WORK	
A	SILO OUTSIDE	Rp 1.397.825.410
B	SILO INSIDE	Rp 3.404.086.000
C	SILO ROOF	Rp 366.000.000
D	**Pellet Silo Lama (A)**	
I	PREPARATION WORK	
A	SILO OUTSIDE	Rp 180.000.000
B	SILO INSIDE	Rp 630.000.000
C	SILO ROOF	Rp 150.000.000
II	REPAIR WORK	
A	SILO OUTSIDE	Rp 788.856.500
B	SILO INSIDE	Rp 698.804.800
C	SILO ROOF	Rp 841.881.000
E	**Pellet Silo Lama (B)**	
I	PREPARATION WORK	
A	SILO OUTSIDE	Rp 180.000.000
B	SILO INSIDE	Rp 630.000.000
C	SILO ROOF	Rp 150.000.000
D	MAT FOUNDATION	Rp 50.000.000
II	REPAIR WORK	
A	SILO OUTSIDE	Rp 1.289.121.500
B	SILO INSIDE	Rp 863.406.800
C	SILO ROOF	Rp 366.000.000
D	MAT FOUNDATION	Rp 1.496.623.700
JUMLAH		**Rp 28.011.000.000**

Source: Project Document, 2024

b. Time schedules are divided into two groups, among others:

a) Project Plan Time Schedule

It is a measure of project implementation. In the time schedule there are job descriptions, work volumes, and weight units (%).

b) Time Schedule Actual Project

Same as the project plan time schedule but contains the progress of the work that has been carried out with a description of the weight that has been carried out and that has not been carried out.

c. Weekly Project Report

Is a record of project achievement data that has been achieved every week. This weekly report is used as work realization / earned value data.

3.1.3. Data analysis

a. Planned Value (PV) / BCWS Calculation

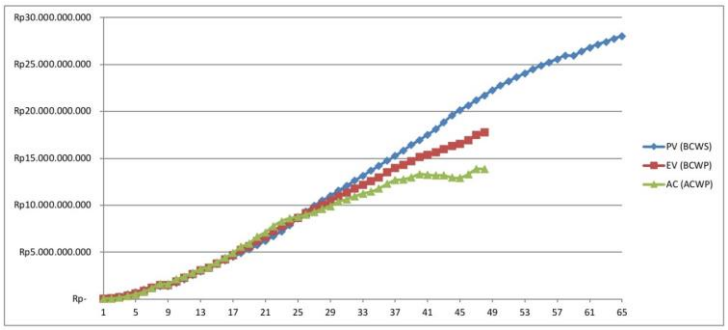
Planned Value (PV) is the budgeted cost of work scheduled for a certain period and specified in the budget, or also called Budgeted Cost of Work Scheduled (BCWS).

PV or BCWS = (% progress plan) x (Budget)
Calculation of PV or BCWS in week 1
PV or BCWS = (% plan) x (Total project budget)
PV or BCWS = (0.27%) x (Rp. 28,011,000,000)
PV or BCWS = Rp 75,629,700

b. Earned Value (EV) or BCWP Calculation

Earned Value (EV) or BCWP is the budgeted cost for work that has been completed, obtained by multiplying the percentage of progress that has been carried out with the budget.

EV or BCWP = (% actual progress) x (Budget)
EV or BCWP calculation in week 1
EV or BCWP = (% actual progress) x (Total project budget)
EV or BCWP = (0.23%) x (Rp. 28,011,000,000)
EV or BCWP = Rp. 64,425,300



Source: 2024 Analysis Results

Figure 1. Comparison Chart between Planned Value (PV), Earned Value (EV) and Actual Cost (AC)

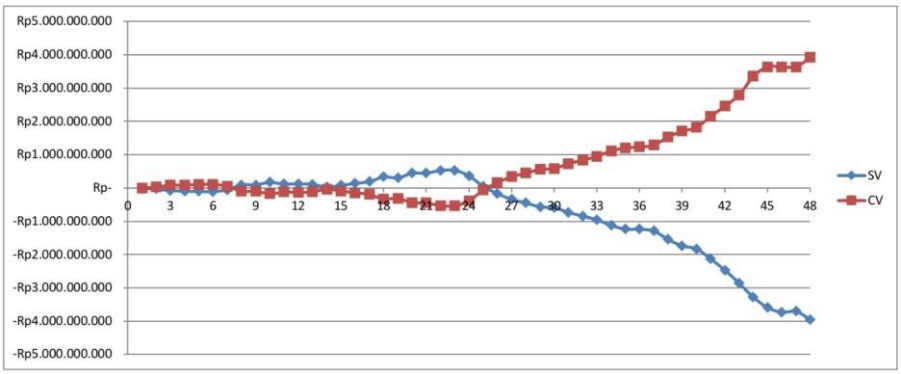
1) In week 26 to week 48 the project experienced delays in work, this is indicated by the value of EV or BCWP which is smaller than the value of PV or BCWS.
2) For actual costs or ACWP in week 26 to week 48, the cost expenditure is smaller with the ACWP graph marked lower than EV / BCWP.

c. Schedule Variance (SV) Calculation
SV is obtained from subtracting BCWP from BCWS:

SV calculation in week 1
SV = (BCWP) - (BCWS)
SV = (Rp. 64.425.300) - (Rp. 75.629.700)
SV = Rp. 11.204.400
SV calculation in week 48
SV = (BCWP) - (BCWS)
SV = (Rp. 17.758.974.000) - (Rp. 21.708.525.000)
SV = - Rp. 3.949.551.000

d. Cost Variance (CV) Calculation
CV is obtained from subtracting BCWP from ACWP:

CV calculation for week 1
CV = (BCWP) - (ACWP)
CV = (Rp. 64.425.300) - (Rp. 64.425.300)
CV = Rp. 0
CV calculation for week 48
CV = (BCWP) - (ACWP)
CV = (Rp. 17.758.974) - (Rp. 13.837.434.000)
CV = Rp. 3.921.540.000



Source: 2024 Analysis Results

Figure 2. Comparison Chart of Schedule Variance (SV), Cost Variance (AC)

1) Project analysis in week - 1, SV (negative) and CV (zero / within budget) values indicate that the work was completed late at a cost within budget.

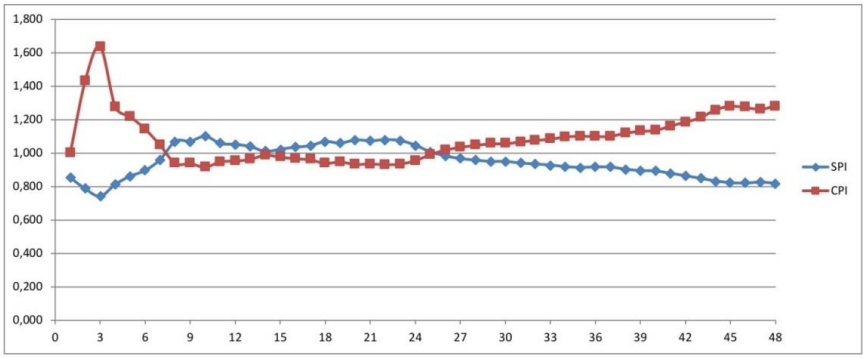
2) Project analysis at week 2 to week 7, the SV (negative) and CV (positive) values indicate that the work was completed later than planned at a cost lower than the budget
3) Project analysis in week 8 to week 25, the SV (positive) and CV (negative) values indicate that the work was completed ahead of plan at a cost higher than the budget
4) Project analysis at week 26 to week 48, the SV (negative) and CV (positive) values indicate that the work was completed later than planned at a lower cost than budget.

e. Calculations Schedule Performance index (SPI)
SPI is obtained from BCWP divided by BCWS:

SPI calculation in week 1
SPI = BCWP / BCWS
SPI = (Rp. 64.425.300) / (Rp. 75.629.700)
SPI = 0,825
SPI calculation in week 48
SPI = BCWP / BCWS
SPI = (Rp. 17.758.974.000) / (Rp. 21.708.525.000)
SPI = 0,818

f. Cost Performance index (CPI) calculation
CPI is obtained from BCWP divided by ACWP:

CPI calculation in week 1
CPI = BCWP / ACWP
CPI = (Rp. 64.425.300) - (Rp. 64.425.300)
CPI = 1
CPI calculation in week 48
CPI = BCWP / ACWP
CPI = Rp. 17.758.974) / (Rp. 13.837.434.000)
CPI = 1,283



Source: 2024 Analysis Results

Figure 3. Comparison Chart of Schedule Performance index (SPI), Cost Performance index (CPI)

Analyze project performance:

1) Project analysis in week - 1, SPI value is < 1 and CPI value is 1 indicating that the work was completed late at a cost within budget.
2) Project analysis in week 2 to week 7, the SPI value is < 1 and the CPI value is > 1 indicating that the work was completed later than planned at a lower cost than budget.
3) Project analysis in week 8 to week 25, the SPI value is > 1 and the CPI value is < 1 indicating that the work was completed faster than planned at a higher cost than budgeted
4) Project analysis at week 26 to week 48, the SPI value is < 1 and the CPI value is > 1 indicating that the work was completed later than planned at a lower cost than budget.

g. Estimate To Complete (ETC) Calculation
ETC of contract value minus BCWS then divided by CPI.

ETC calculation for week 1
ETC = (Total Budget – BCWP) / CPI
ETC = (Rp. 28.011.000.000 - Rp. 64.425.300) / 1
ETC = Rp. 27.946.574.700
ETC calculation for week 48
ETC = (Total Budget – BCWP) / CPI
ETC = (Rp. 28.011.000.000 - Rp. 17.758.974.000) / 1,283
ETC = Rp. 7.988.171.678

h. Estimate At Complete (ETC) Calculation
EAC of ACWP plus ETC:

ETC calculation for week 1
EAC = ACWP + ETC
EAC = Rp. Rp. 64.425.300 + Rp. 27.946.574.700
EAC = Rp. 28.011.000.000
ETC calculation in week 48
EAC = ACWP + ETC
EAC = Rp. Rp. 13.837.434.000 + Rp. 7.988.171.678
EAC = Rp. 21.825.605.678

i. Estimate Temporary Schedule (ETS) calculation
ETS of remaining time divided by SPI:
ETS calculation in week 01
ETS = Time remaining / SPI
ETS = 448 / 0.852
ETS = 525.913 Days

j. Estimate All Schedule (EAS) calculation
EAS of Finish Time plus ETS:
EAS calculation in week 01
EAS = Finish Time + ETS
EAS = 7 + 525.913
EAS = 532.913 Days

Table 2. Estimate Temporary Schedule & Estimate All Schedule

MINGGU	SPI	WAKTU RENCANA (HARI)	WAKTU SELESAI (HARI)	SISA WAKTU (HARI)	ETS (HARI)	EAS (HARI)	SELISIH WAKTU (HARI)
1	0,852	455	7	448	525,913	532,913	-77,913
2	0,786	455	14	441	561,273	575,273	-120,273
3	0,740	455	21	434	586,182	607,182	-152,182
4	0,812	455	28	427	526,014	554,014	-99,014
5	0,861	455	35	420	487,803	522,803	-67,803
6	0,895	455	42	413	461,358	503,358	-48,358
7	0,960	455	49	406	422,723	471,723	-16,723
8	1,070	455	56	399	372,897	428,897	26,103
9	1,070	455	63	392	366,355	429,355	25,645
10	1,100	455	70	385	350,102	420,102	34,898
11	1,056	455	77	378	357,834	434,834	20,166
12	1,051	455	84	371	353,036	437,036	17,964
13	1,038	455	91	364	350,642	441,642	13,358
14	1,008	455	98	357	354,025	452,025	2,975
15	1,023	455	105	350	342,279	447,279	7,721
16	1,034	455	112	343	331,717	443,717	11,283
17	1,043	455	119	336	322,000	441,000	14,000
18	1,069	455	126	329	307,888	433,888	21,112
19	1,058	455	133	322	304,378	437,378	17,622
20	1,078	455	140	315	292,195	432,195	22,805
21	1,072	455	147	308	287,294	434,294	20,706
22	1,079	455	154	301	278,919	432,919	22,081
23	1,074	455	161	294	273,834	434,834	20,166
24	1,046	455	168	287	274,310	442,310	12,690
25	1,006	455	175	280	278,194	453,194	1,806
26	0,982	455	182	273	278,009	460,009	-5,009
27	0,966	455	189	266	275,306	464,306	-9,306
28	0,957	455	196	259	270,575	466,575	-11,575
29	0,949	455	203	252	265,512	468,512	-13,512
30	0,949	455	210	245	258,159	468,159	-13,159
31	0,940	455	217	238	253,279	470,279	-15,279
32	0,933	455	224	231	247,500	471,500	-16,500
33	0,928	455	231	224	241,508	472,508	-17,508
34	0,918	455	238	217	236,375	474,375	-19,375
35	0,913	455	245	210	229,957	474,957	-19,957
36	0,916	455	252	203	221,531	473,531	-18,531
37	0,915	455	259	196	214,104	473,104	-18,104
38	0,903	455	266	189	209,382	475,382	-20,382
39	0,894	455	273	182	203,534	476,534	-21,534
40	0,893	455	280	175	196,065	476,065	-21,065
41	0,878	455	287	168	191,257	478,257	-23,257
42	0,864	455	294	161	186,391	480,391	-25,391
43	0,848	455	301	154	181,558	482,558	-27,558
44	0,833	455	308	147	176,552	484,552	-29,552
45	0,822	455	315	140	170,321	485,321	-30,321
46	0,820	455	322	133	162,286	484,286	-29,286
47	0,825	455	329	126	152,654	481,654	-26,654
48	0,818	455	336	119	145,465	481,465	-26,465

Source: 2024 Analysis Results

ETS calculation in week 48
ETS = Remaining time / SPI
ETS = 119 / 0.818
ETS = 145.465 Days

EAS calculation in week 48
EAS = Finish Time + ETS

EAS = 336 + 145.465
EAS = 481.465 Days

4. CONCLUSION

Based on the conducted analysis, the research concludes that the project experienced various phases of completion relative to the budget and schedule. In Week 1, work was delayed but remained within budget. Weeks 2 to 7 saw delays at a lower cost than budgeted, while Weeks 8 to 25 achieved faster completion at a higher cost. From Weeks 26 to 48, work was again delayed but at a reduced cost. The estimated total cost to complete the project is Rp. 21,825,605,678, which is 0.77% less than the contract value of Rp. 28,011,000,000, and the project duration extended by 26 days, resulting in a 0.6% increase over the contracted 455 days.

To meet earlier deadlines, additional working hours or labor could be arranged, although this would raise costs beyond initial estimates. Despite this, the projected profit margin remains above 10%, suggesting profitability. Future research is recommended to focus on improving control measures for job scheduling.

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