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Analysis Of The Application Of Time Management In Building Projects With Critical Path Method (Cpm) And Earned Value Method (Evm)

(Case Study: Jakarta Islamic Hospital Pondok Kopi)

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Abstract

This study analyzes the implementation of time management in construction projects using the Critical Path Method (CPM) and Earned Value Method (EVM) methods in the construction project of the Jakarta Islamic Hospital Pondok Kopi. This research is motivated by the importance of time control in project implementation to minimize delays. The methods used include work network analysis using CPM to determine the critical path and duration of the project, as well as time performance analysis using EVM through the parameters of Planned Value (PV), Earned Value (EV), Schedule Variance (SV), and Schedule Performance Index (SPI). The results of the CPM analysis show that the duration of the project completion is 274 days, faster than the duration of the plan on the S curve which is 287 days. However, the results of the EVM analysis show that the project time performance is delayed, which is shown by the Schedule Performance Index (SPI) value of 0.77061 and the Schedule Variance (SV) value of negative. This indicates that the actual progress of the project is lower compared to the plan that has been set. Thus, although the project has the potential to be completed faster in terms of planning based on CPM analysis, the actual conditions on the ground indicate that the project is delayed. Therefore, more optimal control is needed, especially on critical path activities, to improve project time performance.

Keywords: *Time Management, CPM, EVM, Schedule Performance Index (SPI), Schedule Variance (SV)*

INTRODUCTION

Construction projects involve complex processes and multiple stakeholders and involve various parties with the aim of achieving set time, cost, and quality targets. In its implementation, construction projects have a high level of uncertainty due to various risks that can affect project performance, especially in terms of time. Project delays are still a common problem, both globally and in Indonesia, which can have an impact on increasing costs and decreasing the effectiveness of project implementation (Ibrahim et al., 2022). Therefore, time management is one of the important aspects in ensuring the success of construction projects.
Project time management plays a role in systematically integrating work activities, resources, and costs so that project

implementation can run according to plan. However, in practice, there are still many projects that experience delays due to suboptimal planning, ineffective coordination, and weak time control systems (dina amalia ahmad, 2024). The Critical Path Method (CPM) method is used to identify critical paths and determine the minimum duration of the project, while the Earned Value Method (EVM) is used to evaluate the project's time performance through a comparison between the plan and the realization of the execution of the work (Yuwono et al., 2021).

Previous studies have shown that CPM is effective in determining project duration and identifying critical paths, while EVM is effective in evaluating project performance and detecting schedule deviations. However, most studies have applied these methods separately, resulting in analyses that focus only on project planning or performance evaluation. Research integrating CPM and EVM simultaneously, particularly in hospital building construction projects, remains relatively limited. Therefore, a more comprehensive analysis that combines project planning evaluation and actual project performance assessment is required.

The novelty of this study lies in the integration of CPM and EVM methods to evaluate planned project duration and actual schedule performance in the building construction project. By combining these two approaches, this study not only identifies critical paths and optimal project duration but also evaluates project schedule performance using time performance indicators. The integration of these methods is expected to provide a more comprehensive understanding of construction project time management and support more effective project control decision-making.

Based on the foregoing discussion, this study aims to analyze the implementation of time management in the building construction project using the Critical Path Method (CPM) and Earned Value Method (EVM). The results are expected to provide information regarding project duration, critical path activities, and project schedule performance, while also contributing to improving the effectiveness of time control in construction projects.

Time Management

Project time management plays a crucial role in the success of construction projects, especially in hospital projects that have complex characteristics and involve various parties. Project management is planning, organizing, dreaming, and controlling the company's resources to achieve short-term, predetermined goals, and using a vertical and horizontal system and hierarchy approach (Revistar, Graha, and Malang 2016).

Critical Path Method

The Critical Path Method (CPM) serves to identify the critical path of the project, which is the set of activities that determine the overall duration of the project, so that the project manager can focus on those activities and take corrective action in case of delays. CPM essentially emphasizes the importance of a balance between expenses and the duration of completion of major projects. CPM assumes that the time of each activity is clearly known, so only one measure is needed for each activity (Metode et al. 2012).

Earned Value Method

Meanwhile, the *Earned Value Method* (EVM) is used to measure project performance in an integrated manner, combining time and cost aspects while providing information on project status, estimated costs and completion times, and potential future issues (Sufa'atin 2017).

METHOD

This study employed a quantitative approach with a descriptive method through a case study of the Jakarta Islamic Hospital Pondok Kopi Parking Building construction project located in East Jakarta. The quantitative approach was selected because the research utilized numerical data obtained from project planning and implementation documents, while the descriptive method was used to systematically describe the actual conditions of project execution based on available project data.

The data used in this study consisted of secondary data obtained from project documentation, including project schedules (time schedules), Bill of Quantity (BOQ), planned S-curve data, weekly progress reports, and project cost data. Project

performance observation was conducted up to week 34 based on the availability of actual project progress data. In addition, a literature review was carried out to obtain theoretical foundations and references supporting the research analysis.

The research object consisted of 46 work activities analyzed using the Critical Path Method (CPM) and Earned Value Method (EVM). In the CPM analysis, activity data, durations, and dependency relationships among activities were used to develop the project network diagram, identify the critical path, and calculate the total project duration. Calculations were performed using forward pass and backward pass procedures to determine the Early Start (ES), Early Finish (EF), Late Start (LS), and Late Finish (LF) values. The critical path was identified based on activities with zero float.

Furthermore, EVM analysis was applied to evaluate project schedule performance by comparing planned progress with actual progress. The parameters used included Planned Value (PV), Earned Value (EV), Schedule Variance (SV), and Schedule Performance Index (SPI). PV was calculated by multiplying the planned progress percentage by the Budget at Completion (BAC), while EV was calculated by multiplying the actual progress percentage by the BAC. Subsequently, SV and SPI were calculated to assess schedule deviation and project time performance.

The results obtained from CPM and EVM analyses were then interpreted in an integrated manner to evaluate the effectiveness of time management implementation in the Jakarta Islamic Hospital Pondok Kopi construction project. The integration of both methods was used to compare the planned project duration with actual schedule performance during project execution, thereby identifying potential delays and evaluating the effectiveness of project time control.

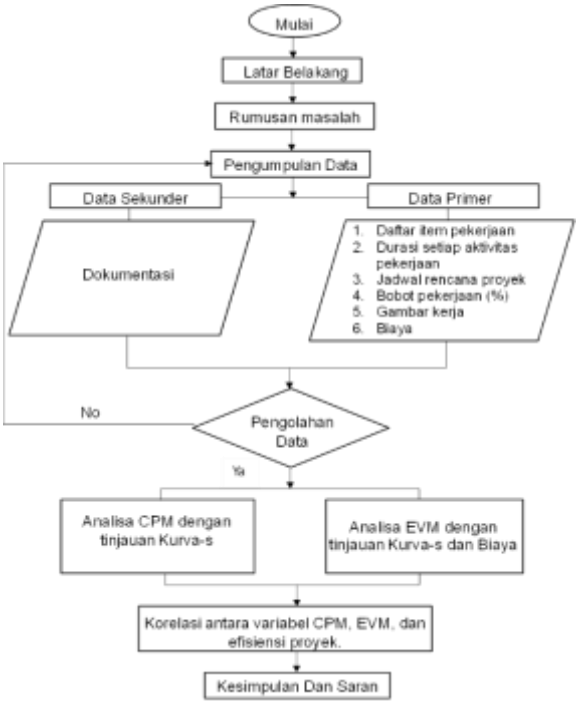


Figure 1. Critical Path Network Diagram

RESULTS AND DISCUSSION

Conversion Duration

Project schedule data that was originally presented in weekly form was first converted to units of days to facilitate project duration analysis and time control.

Example Calculation:

Calculation of Prep Work

Volume = 118.44 m^1

Coeficin = 1,053

Productivity = $\frac{1}{Koefisien}$

= $\frac{1}{1{,}053}$

= 0.9497

Pro. Worker = Productivity × Workers

= 0.9497 × 10

= 4.7483

Duration = $\frac{Volume}{Produktivitas\ Pekerja}$

= $\frac{118{,}44}{4{,}7483}$

= 12.47 days = 13 days

Tabel 1. Duration Conversion Results

No	Item	Volume	Koef	Produktivitas	Produktivitas Pekerja	Duras
		a	b	(1/b)	((1/b)xc)	(((1/b)xc
1	PEKERJAAN PERSIAPAN	118,44	1,05	0,95	9,50	12,47
	PEKERJAAN TANAH					
2	Pekerjaan Galian	1446,16	0,03	37,31	111,94	12,92
3	Urugan Tanah Kembali	572,92	0,03	37,31	111,94	5,12
4	Urugan Pasir Bawah Pilecap	59,42	0,32	3,17	6,35	9,36
5	Pekerjaan Buang Tanah sisa Galian Pilecap	885,28	0,06	15,56	155,62	5,69
6	Antirayap	1109,30	0,01	74,07	148,15	7,49
7	Pemadatan Tanah	859,00	0,01	112,36	224,72	3,82
8	Repair kanstin	1,00	0,05	19,34	19,34	0,05
9	Aspal Hotmix	735,00	0,21	4,74	71,16	10,33
10	Repair Gate ACP	1,00	0,26	3,88	7,75	0,13
	PEKERJAAN STRUKTUR PONDASI					
11	Pondasi Bored Pile dia 60cm	1312,50	0,52	1,91	28,64	45,82
12	Mob de mob Alat Pancang (HSPD 420 ton)	56,00	0,07	14,75	14,75	3,80
13	Jasa Pemasangan Spun Pile	784,00	0,07	14,75	73,75	10,63
14	Handling	784,00	0,07	14,75	73,75	10,63
15	Joint Welding	56,00	0,01	104,17	104,17	0,54
16	Potong Tiang Pancang	56,00	0,05	20,00	60,00	0,93
17	Peilcap, K-350 F6C	23,34	1,63	0,61	3,68	6,35
18	Peilcap, K-350 F6D	25,74	1,63	0,61	3,68	7,00
19	Peilcap, K-350 F10	25,24	1,63	0,61	3,68	6,86
20	Peilcap, K-350 F11	33,02	1,63	0,61	4,90	6,73

Graphic 1. Comparison of S-curve and CPM result durations

The data is then used as a basis for the preparation of the project work network using the Critical Path Method (CPM) method and time performance calculation using the Earned Value Method (EVM).

CPM Method Analysis

The analysis using the Critical Path Method (CPM) method was carried out to determine the critical path and the total duration of the project. This stage of analysis includes the preparation of a network diagram, as well as the calculation of the start and end time of each activity.

1. Relationship of Dependency Between Jobs

   The relationship between jobs in a construction project shows the relationship between activities that are interdependent with each other. Each job has a predecessor and successor activity that determines the order of project implementation.

Tabel 2. Sequence of Dependencies Between Jobs

No	Item	Kode Pendahulu
1	**PEKERJAAN PERSIAPAN**	
	PEKERJAAN TANAH	
2	Pekerjaan Galian	1
3	Urugan Tanah Kembali	4
4	Urugan Pasir Bawah Pilecap	2
5	Pekerjaan Buang Tanah sisa Galian Pilecap	2
6	Antirayap	2
7	Pemadatan Tanah	1
8	Repair kanstin	7
9	Aspal Hotmix	38
10	Repair Gate ACP	9
	PEKERJAAN STRUKTUR PONDASI	
11	Pondasi Bored Pile dia 60cm	2
12	Mob de mob Alat Pancang (HSPD 420 ton)	3,5,6,8,11
13	Jasa Pemasangan Spun Pile	12
14	Handling	12
15	Joint Welding	12
16	Potong Tiang Pancang	12
17	Peilcap, K-350 F6C	19,20,21,22,23,24,25
18	Peilcap, K-350 F6D	19,20,21,22,23,24,25
19	Peilcap, K-350 F10	13,14,15,16
20	Peilcap, K-350 F11	13,14,15,16

2. Forward Pass

   In the initial activity, the Early Start (ES) value is set at zero. As for activities that have more than one predecessor, the Early Start (ES) value is determined based on the largest Early Finish (EF) value of the predecessor activities.

   $$EF = ES + D$$
   $$ES = max(EF) \quad (1)$$

   Where:
   ES = Early Start
   EF = Early Finish
   D = Duration
   Here's an example of the calculation:
   Duration = 13 days
   ES = 0
   EF = 13 + 0
   = 13 days

Tabel 3. Results of Forward

No	Item	Duration	Early Start
1	**PEKERJAAN PERSIAPAN**	184	0
	PEKERJAAN TANAH		
2	Pekerjaan Galian	13	184
3	Urugan Tanah Kembali	6	207
4	Urugan Pasir Bawah Pilecap	10	197
5	Pekerjaan Buang Tanah sisa Galian Pilecap	6	197
6	Antirayap	8	197
7	Pemadatan Tanah	4	184
8	Repair kanstin	1	188
9	Aspal Hotmix	12	445
10	Repair Gate ACP	1	457
	PEKERJAAN STRUKTUR PONDASI		
11	Pondasi Bored Pile dia 60cm	58	197
12	Mob de mob Alat Pancang (HSPD 420 ton)	4	255
13	Jasa Pemasangan Spun Pile	11	259
14	Handling	11	259
15	Joint Welding	1	259
16	Potong Tiang Pancang	1	259
17	Peilcap, K-350 F6C	7	284
18	Peilcap, K-350 F6D	7	284
19	Peilcap, K-350 F10	7	270
20	Peilcap, K-350 F11	7	270

Tabel 4. Results Backward Pass

No	Item	Duration	Late Start	Late Finish
1	**PEKERJAAN PERSIAPAN**	184	0	13
	PEKERJAAN TANAH			
2	Pekerjaan Galian	13	13	26
3	Urugan Tanah Kembali	6	66	72
4	Urugan Pasir Bawah Pilecap	10	56	66
5	Pekerjaan Buang Tanah sisa Galian Pilecap	6	66	72
6	Antirayap	8	64	72
7	Pemadatan Tanah	4	67	71
8	Repair kanstin	1	71	72
9	Aspal Hotmix	12	262	273
10	Repair Gate ACP	1	273	274
	PEKERJAAN STRUKTUR PONDASI			
11	Pondasi Bored Pile dia 60cm	58	26	72
12	Mob de mob Alat Pancang (HSPD 420 ton)	4	72	76
13	Jasa Pemasangan Spun Pile	11	76	87
14	Handling	11	76	87
15	Joint Welding	1	86	87
16	Potong Tiang Pancang	1	86	87
17	Peilcap, K-350 F6C	7	101	108
18	Peilcap, K-350 F6D	7	101	108
19	Peilcap, K-350 F10	7	94	101
20	Peilcap, K-350 F11	7	94	101

3. Backward Pass

This calculation starts from the final project activity to the initial activity by following the dependency relationship between activities.

$$LS = LF - D$$

$$LF = min(LS) \quad (2)$$

Where:
LS = Late Start
LF = Late Finish
D = Duration
Here's an example of the calculation:
Duration = 1 day
LF = EF last job
= 274
LS = 274 - 1
= 273 days

4. Determining the Critical Path

Critical paths are defined based on activities that have a float value equal to zero, which means they have no time allowance and greatly affect the total duration of the project.

Float = Late Finish – Early Finish

$$Float = 0, Critical\ path \quad (3)$$

Here's an example of the calculation:
LF = 131
EF = 131
Float = 131 - 131
= 0, critical path

The results of the CPM analysis show that the total duration of project completion is 274 days, which is obtained from the critical path as a series of activities without time lag (float = 0). This critical path is the main determinant of the duration of the project, so any delay in the activity will have a direct impact on the overall project completion time.

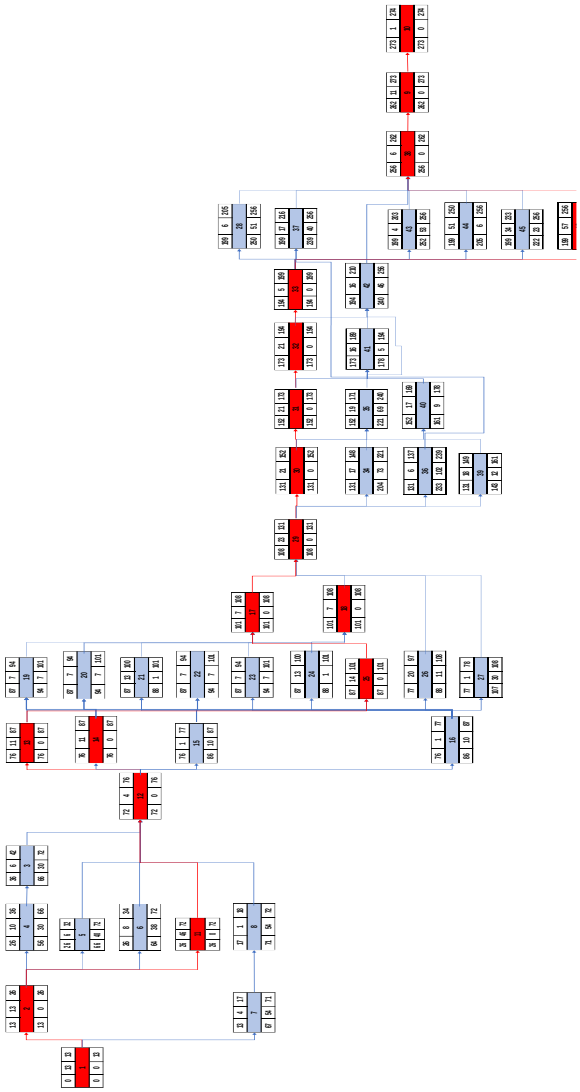


Figure 2. Critical Path Network Diagram

EVM Method Analysis

The analysis using the Earned Value Method (EVM) was carried out to evaluate the project's time performance by comparing the plan and the realization of the work.

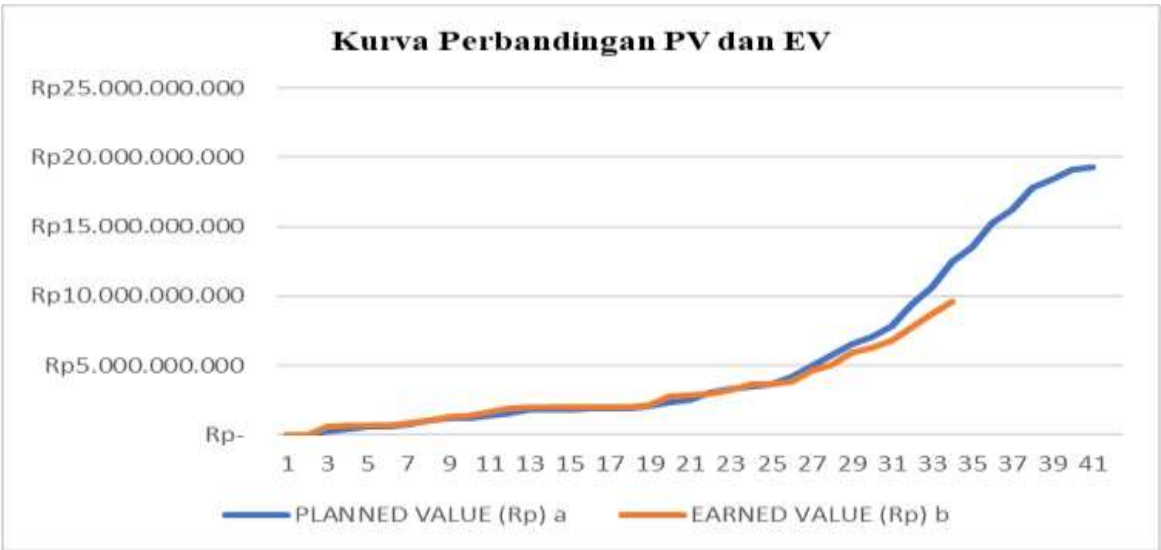
1. Planned Value (PV)
   The calculation of Planned Value (PV) is carried out by multiplying the percentage of the work plan by the total project value or BAC (Budget at Completion).
   PV = % Plan Progress × BAC (4)
   Here's an example of the calculation:
   Plan Progress = 0.03%
   PV = Plan Progress x BAC
   = 0.03% × IDR 19,337,551,642.
   = IDR 5.801.265
2. Earned Value (EV)
   The calculation of Earned Value (EV) is done by multiplying the percentage of actual progress by the total project value or Budget at Completion (BAC).
   EV = % Current Progress × BAC
   Here's an example of the calculation:
   Current Progress = 3.63%
   EV = Current Progress x BAC
   = 3.63% ×IDR 19,337,551,642.
   = IDR 701.953.124.59
3. Schedule Variance (SV)
   SV calculation is carried out in each time period to determine the gradual development of project time performance.
   SV = EV – PV
   SV > 0, then the project is faster than the planned schedule
   SV = 0, then the project is on schedule
   SV < 0, then the project is delayed
   Here's an example of the calculation:
   PV = IDR 3,018,591,811
   EV= IDR 2,972..181,687
   SV= IDR 2,972,181,687 –
   IDR 3,018,591,811
   = IDR – 46,410,124
4. Schedule Performance Index (SPI)
   SPI calculation is carried out in each time period to determine the level of efficiency of project implementation against the planned schedule.
   $SPI = \frac{EV}{PV}$
   Where:
   SPI = Schedule Performance Index
   EV = Earned Value
   PV = Planned Value
   SPI>1, indicates the project is faster than planned
   SPI=1, indicates the project as planned
   SPI<1, shows that the project is delayed
   Here's an example of the calculation:
   PV= IDR 1,195,060,691
   EV= IDR 1,417,442,535

   $SPI = \frac{IDR\ 1.417.442.535}{IDR\ 1.195.060.691}$

   = 1.18608

Tabel 5. Results of EVM Method Analysis

MNG	PLANNED VALUE (Rp) a	EARNED VALUE (Rp) b	Schedule Variance (Rp) (b-a)	Schedule Performance Index (b/a)	Status	Status
1	Rp 5.801.265	Rp -	-Rp 5.801.265	0,00000	Terlambat	Terlambat
2	Rp 11.602.531	Rp -	-Rp 11.602.531	0,00000	Terlambat	Terlambat
3	Rp 206.911.803	Rp 597.530.346	Rp 390.618.543	2,88785	LebihCepat	Lebih Cepat
4	Rp 402.221.074	Rp 701.953.125	Rp 299.732.050	1,74519	LebihCepat	Lebih Cepat
5	Rp 597.530.346	Rp 701.953.125	Rp 104.422.779	1,17476	LebihCepat	Lebih Cepat
6	Rp 603.331.611	Rp 701.953.125	Rp 98.621.513	1,16346	LebihCepat	Lebih Cepat
7	Rp 798.640.883	Rp 895.328.641	Rp 96.687.758	1,12107	LebihCepat	Lebih Cepat
8	Rp 993.950.154	Rp 1.032.625.258	Rp 38.675.103	1,03891	LebihCepat	Lebih Cepat
9	Rp 1.189.259.426	Rp 1.320.754.777	Rp 131.495.351	1,11057	LebihCepat	Lebih Cepat
10	Rp 1.195.060.691	Rp 1.417.442.535	Rp 222.381.844	1,18608	LebihCepat	Lebih Cepat
11	Rp 1.390.369.963	Rp 1.653.360.665	Rp 262.990.702	1,18915	LebihCepat	Lebih Cepat
12	Rp 1.585.679.235	Rp 1.927.953.899	Rp 342.274.664	1,21585	LebihCepat	Lebih Cepat
13	Rp 1.844.802.427	Rp 1.958.893.981	Rp 114.091.555	1,06184	LebihCepat	Lebih Cepat
14	Rp 1.850.603.692	Rp 1.958.893.981	Rp 108.290.289	1,05852	LebihCepat	Lebih Cepat
15	Rp 1.856.404.958	Rp 1.958.893.981	Rp 102.489.024	1,05521	LebihCepat	Lebih Cepat
16	Rp 1.862.206.223	Rp 1.958.893.981	Rp 96.687.758	1,05192	LebihCepat	Lebih Cepat
17	Rp 1.868.007.489	Rp 1.958.893.981	Rp 90.886.493	1,04865	LebihCepat	Lebih Cepat
18	Rp 1.873.808.754	Rp 1.958.893.981	Rp 85.085.227	1,04541	LebihCepat	Lebih Cepat
19	Rp 2.080.720.557	Rp 2.200.613.377	Rp 119.892.820	1,05762	LebihCepat	Lebih Cepat
20	Rp 2.341.777.504	Rp 2.813.613.764	Rp 471.836.260	1,20149	LebihCepat	Lebih Cepat



Graphic 2. Comparison of PV and EV

Based on the Earned Value Method (EVM) calculation, a Schedule Performance Index (SPI) value of 0.77061 and a Schedule Variance (SV) value of IDR -2,867,758,908 were obtained at week 34. SPI < 1 indicates that the achieved project progress was lower than the planned progress. Meanwhile, the negative SV value indicates a deviation between the earned value and the planned value that should have been achieved according to the project schedule. These results indicate that the project experienced schedule delays during implementation.

The project delay indicated by the SPI and SV values may be attributed to several factors. One of the most influential factors is the delay in activities located on the critical path. In CPM analysis, critical path activities have no time allowance (float = 0), meaning that any delay occurring in these activities directly affects the overall project completion time. In addition, limited resources, material procurement delays, ineffective work coordination, and operational constraints in the field may also contribute to the inability of actual progress to meet planned targets.

The findings show that although CPM analysis estimated a project duration of 274 days, which is shorter than the planned duration of 287 days based on the S-curve schedule, the actual project performance experienced delays. This finding indicates that the optimal duration obtained during project planning cannot always be achieved if project implementation is not supported by effective monitoring and control throughout the

construction process. In other words, successful project planning must be accompanied by continuous supervision and control to ensure that schedule targets can be achieved.

The results of this study are consistent with the findings of Surya Wibowo (2020), who reported that CPM is effective for determining optimal project duration, while EVM is capable of identifying schedule deviations during project execution. Furthermore, Sidiq and Johari (2022) also found that an SPI value below one indicates project delay and highlights the need for corrective actions to prevent further schedule overruns. These similarities demonstrate that EVM is an effective tool for evaluating project schedule performance and detecting potential delays at an early stage.

Therefore, the integration of CPM and EVM in this study provides a more comprehensive evaluation of project time management. CPM is useful for identifying critical activities and determining optimal project duration, while EVM evaluates actual schedule performance based on project progress. The combination of these methods can serve as a basis for decision-making aimed at improving time control effectiveness and minimizing delay risks in construction projects.

CONCLUSION

Based on the results of the time management analysis conducted on the Jakarta Islamic Hospital Pondok Kopi construction project using the Critical Path Method (CPM) and Earned Value Method (EVM), the following conclusions can be drawn:

1. The CPM analysis indicated that the project completion duration was 274 days. This duration was obtained from the identified critical path consisting of activities with zero float values. Therefore, any delay occurring within these activities would directly affect the overall project completion time.
2. The EVM analysis up to week 34 resulted in a Schedule Variance (SV) value of IDR -2,867,758,908 and a Schedule Performance Index (SPI) value of 0.77061. The negative SV value and SPI value lower than one indicate that the actual project progress was below the planned progress, meaning that the project experienced schedule delays during implementation.
3. The comparison between CPM and EVM results reveals a discrepancy between project planning and actual project performance. Based on CPM analysis, the project had the potential to be completed within 274 days, which was faster than the planned duration of 287 days indicated by the S-curve schedule. However, EVM results demonstrated that the project experienced delays during execution. This finding suggests that successful project scheduling must be supported by effective monitoring and control throughout the implementation stage.
4. From a practical perspective, the integration of CPM and EVM can serve as a comprehensive project time control tool. CPM assists in identifying critical activities requiring special attention, while EVM provides periodic information regarding project schedule performance, enabling potential delays to be detected at an early stage.

This study has several limitations. The EVM analysis was conducted only based on schedule performance indicators up to week 34 due to the availability of project data. In addition, the study did not comprehensively evaluate project cost performance through Cost Variance (CV) and Cost Performance Index (CPI) indicators.

Therefore, future studies are recommended to integrate both schedule and cost performance analyses using a more comprehensive Earned Value Management (EVM) approach and apply the methodology to different types of construction projects in order to obtain broader and more comparative results.

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