CHAPTER 15

Analyzing Construction Delays using Microsoft Project and Earned Value Analysis

Saif Shafi Qureshi[1] *and Pravinchandra Gaikwad*[2]

ABSTRACT

Efficient construction project management is the key to ensure projects are completed on time, within budget, to the required quality standards and with proper safety management system. By incorporating proper planning, timely decision making and strategies, construction project managers can ensure efficient project delivery, minimize risks and maximize stakeholder satisfaction. In the present study MSP schedule is prepared for a multistoried building project. Tracking of the project progress against schedules, budgets is carried out in order to identify construction project delays and mitigation measures have been suggested. The study highlights the importance of planning and strategic decision making from the beginning of the project in order to ensure its timely completion. Numerous factors, including team member's qualifications, mandatory approvals from local authority, timely appointment of subcontractor and external environmental concerns are identified as major drivers to project delays. Project delays can be reduced by putting best practices in place for coordination, planning, progress monitoring and frequent meetings. This will result in successful project outcome.

Keywords: Project management; Planning; decision-making; construction delays; preventive measures.

1.0 Introduction

Construction projects often face delays and cost overruns, making it hard to finish them on time and within budget. These problems lead to financial losses, contract disputes, and wasted resources. Common causes of delays include poor site management, weak communication, and inadequate planning. Analyzing past project data helps with cost control and risk management, there is still a need for better methods to identify and manage delays effectively. By tracking project progress and assessing performance metrics, better project planning, communication, monitoring and execution is possible in construction project. In the present study, residential building project (G+8) is analysed for construction delays using tools like Earned Value Analysis (EVA) to find out key performance indicators.

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However, the study has some limitations. It focuses on a single multi-story building, so the findings may not apply to all types of projects. The accuracy of the results depends on site progress data, which may have errors or missing details. External factors like economic changes, policy updates, and unexpected events are not deeply analyzed. The study mainly relies on Microsoft Project and EVA, without considering other project management tools. It also does not include indirect costs or expenses related to interiors.

2.0 Literature Review

The integration of Earned Value Management (EVM) with big data analysis enhances cost control and risk management by utilizing historical project data for accurate forecasting (Li, 2023). Earned Value Analysis (EVA) provides clear performance metrics that significantly improve project management effectiveness in construction projects (Costa *et al.*, 2022). The Earned Value Method (EVM) serves as a crucial tool for managing construction projects by providing a clear picture of project performance through the integration of scope, costs, and schedules (Czemplik, 2014). Additionally, the application of EVM as a performance measurement tool in construction highlights the need for a balance between financial data and actual project progress (Candido *et al.*, 2014).

Effective scheduling plays a vital role in construction project success, with key factors influencing scheduling activities during planning and implementation (Hansen *et al.*, 2023). Delays in construction projects are often caused by poor site management, inefficient communication, and inadequate data management (Radman *et al.*, 2021). Delay analysis methods, such as As Planned vs. As Built, are essential for identifying the causes of delays and determining accountability (Lari *et al.*, 2019). Owner-related causes account for a significant portion of delays in infrastructure projects, underscoring the need for improved planning and decision-making (Elawia *et al.*, 2016).

The oil and gas sector in Oman faces delays due to poor site management and ineffective communication among stakeholders (Ruqaishi *et al.*, 2013). Similarly, in international development projects funded by the Asian Development Bank, understanding cultural and local factors is crucial for improving planning and execution (Ahsan *et al.*, 2010). In the United States and India, organizational culture plays a role in project delays, with a “clan” culture in U.S. firms leading to fewer delays compared to the “market” culture prevalent in Indian firms (Arditi *et al.*, 2016).

Stakeholder engagement is another critical factor in construction project success, requiring strong relationships among all involved parties (Marzouk *et al.*, 2014). The Technology Acceptance Model (TAM), when integrated with safety management practices, enhances the acceptance of Personal Protective Equipment (PPE) among construction workers (Wong *et al.*, 2021). Moreover, safety performance in construction is influenced by multiple factors, necessitating a hierarchical framework to understand their interactions (Mohammadi *et*

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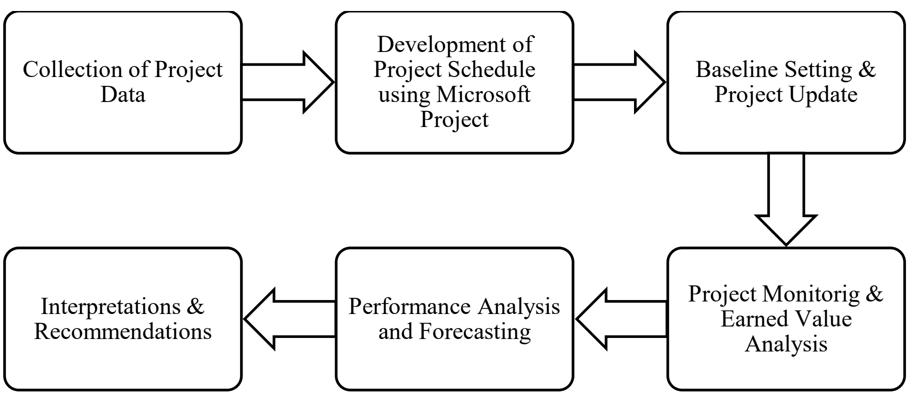
al., 2018). A comprehensive approach to project management is necessary due to the interconnections among various delay factors (Doloi *et al.*, 2012). Identifying these causes is crucial for recommending effective practices to mitigate and avoid project delays (Vacanas *et al.*, 2021).

3.0 Methodology

In the present work a systematic approach is used to analyze construction delays by integrating qualitative and quantitative methods. In this study, a G+8 residential building project from Andheri East, Mumbai is selected, with actual site progress data recorded as 43% completion. A comparative analysis between planned progress and actual progress is recorded. Data collection consist of actual project records, including site progress reports, approved schedules and cost tracking documents. These records are analyzed to evaluate past performance, identify key delay factors and assess their impact on project timelines through comparative analysis between planned and actual progress. To facilitate the analysis, Microsoft Project and Earned Value Analysis (EVA) was utilized. A baseline schedule was developed using Microsoft Project. Deviations were tracked and adjustments were made using Earned Value Analysis (EVA) to assess the efficiency of rescheduling techniques. Key EVA metrics such as Cost Performance Index (CPI) and Schedule Performance Index (SPI) are evaluated to determine efficiency trends and identify potential risks. The data collected is then analyzed to identify key factors contributing to delays and assessing their impact on project timelines and costs. Based on this analysis, practical recommendations are developed to mitigate delays in future construction projects, focusing on improving planning, communication and stakeholder engagement. The findings and recommendations are validated through discussions with industry experts and stakeholders involved in the project, ensuring the relevance and applicability. The methodology adopted in the present work is depicted as shown in Figure 1.

Figure 1: Methodology Flowchart



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4.0 Project Monitoring and Earned Value Analysis

Evaluation of project performance is examined in its 43% completion report. Using MS Project, the analysis compares planned and actual progress, identifies delays and evaluates resource use.

4.1 Project schedule overview

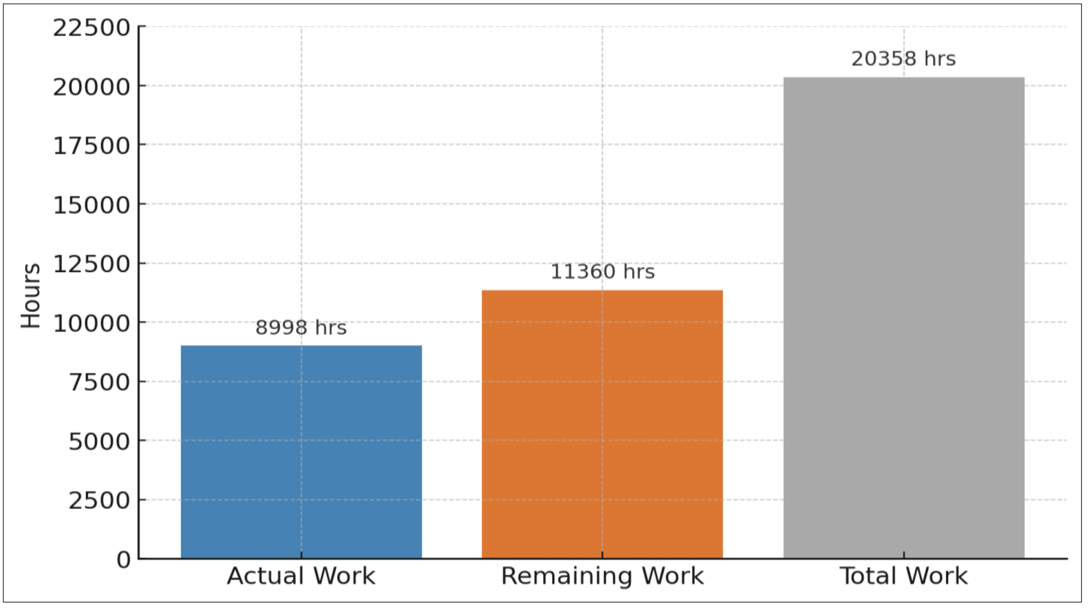
Microsoft Project Software was utilized to establish a baseline schedule and track actual progress. Key scheduling parameters, including baseline start and finish dates, scheduled start and finish and the current percentage of project completion, were analyzed to assess project performance. Table 1 compares planned and actual timelines, offering insights into schedule adherence.

Table 1: Project Schedule Overview

Baseline Start	Baseline Finish	Scheduled Start	Forecasted Finish	% Complete
Fri 01-12-23	Fri 15-11-24	Fri 01-12-23	Tue 10-12-24	43%

To assess the project's current status, a performance evaluation was conducted. The figure below illustrates the comparison between actual work completed, remaining work and the total planned work. This visualization helps in understanding the progress made and the pending work hours as shown in Figure 2.

Figure 2: Project Work Performance Chart



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As observed in Figure 2, out of the total planned 20,358 hours, only 8,998 hours of actual work have been completed, leaving a remaining work balance of 11,360 hours. This indicates that significant efforts are still required to meet the project deadline.

4.2 Delay analysis

The following Table 2 provides a detailed breakdown of delays encountered in individual construction activities. It compares baseline durations with actual progress to quantify the extent of delays in early start or early finish phases.

Table 2: Analysing Delay for Individual Activities

Sr. No.	Task Name	Baseline Duration	Updated Duration	Delay in Early Start of activity	Delay in Early Finish of the activity	Cumulative Delay
	G+8 Residential Building	294 days	315 days			
	Sub Structure	110 days	127 days			
1	General	110 days	127 days			0
2	Surveying & Layout	2 days	2 days			0
3	Pilling	60 days	73 days	3	13	16
4	Excavation	4 days	5 days		1	17
5	Pile Caps	7 days	7 days			17
6	Column upto Plinth Level	13 days	13 days			17
7	Plinth Level Beam and Slab	24 days	24 days			17
	Super Structure	184 days	188 days			
	Ground Floor	20 days	24 days			
	Ground Floor Column	7 days	11 days			
8	Reinforcement	3 days	3 days			17
9	Formwork	2 days	4 days		2	19
10	Concrete Pouring	1 day	1 day	2		21
11	Deshuttering	1 day	1 day	1		22

4.3 Cost variance analysis of individual activities

To evaluate the project's financial efficiency, cost variance was analyzed for each activity. Cost variance analysis of individual activities helps to compare the planned and actual costs for each task in a project. It highlights cost deviations, enabling better budget control and decision-making during further execution of the project.

The Cost Variance Analysis in Table 3 highlights a total project cost overrun of ₹352,822.50, primarily due to increased expenses in superstructure (₹241,095.00), slab construction (₹136,495.00) and reinforcement (₹60,572.50).

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Table 3: Analysing Cost Variance of Individual Construction Activities

	Task Name	Total Cost	Baseline Cost	Actual Cost	Cost Variance
	G+8 Residential Building	₹ 11,105,522.5	₹ 10,752,700.0	₹ 4,301,465.00	₹ 352,822.50
	Sub Structure	₹ 3,913,517.50	₹ 3,319,600.00	₹ 3,913,517.50	₹ 593,917.50
1	General	₹ 3,913,517.50	₹ 3,319,600.00	₹ 3,913,517.50	₹ 593,917.50
2	Surveying & Layout	₹ 7,800.00	₹ 7,800.00	₹ 7,800.00	0.00
3	Pilling	₹ 2,084,062.50	₹ 1,710,000.00	₹ 2,084,062.50	₹ 374,062.50
4	Excavation	₹ 47,662.50	₹ 37,200.00	₹ 47,662.50	₹ 10,462.50
5	Pile Caps	₹ 203,062.50	₹ 199,500.00	₹ 203,062.50	₹ 3,562.50
6	Column up to Plinth Level	₹ 560,935.00	₹ 491,600.00	₹ 560,935.00	₹ 69,335.00
7	Plinth Level Slab	₹ 1,009,995.00	₹ 873,500.00	₹ 1,009,995.00	₹ 136,495.00
	Super Structure	₹ 7,192,005.00	₹ 7,433,100.00	₹ 387,947.50	₹ 241,095.00-
	Ground Floor	₹ 860,847.50	₹ 807,300.00	₹ 387,947.50	53,547.50
	Ground Floor Column	₹ 387,947.50	₹ 300,300.00	₹ 387,947.50	87,647.50
8	Reinforcement	₹ 193,472.50	₹ 132,900.00	₹ 193,472.50	₹ 60,572.50
9	Formwork	₹ 16,000.00	₹ 8,000.00	₹ 16,000.00	₹ 8,000.00
10	Concrete Pouring	₹ 175,100.00	₹ 156,400.00	₹ 175,100.00	₹ 18,700.00
11	Deshuttering	₹3,375.00	₹ 3,000.00	₹3,375.00	₹ 375.00

4.4 Labor cost variance analysis

Labor cost variance analysis helps to track differences between estimated and actual labor costs in a project. It identifies cost overruns or savings, allowing better budget control and resource management.

Table 4: Cost Variance Analysis of Labor Expenses

Name	Cost	Baseline Cost	Cost Variance
Site Engineer	₹ 180,937.50	₹ 201,000.00	-₹ 20,062.50
Supervisor	₹ 119,500.00	₹ 118,000.00	₹ 1,500.00
Head Mason	₹ 45,100.00	₹ 46,400.00	-₹ 1,300.00
Mason	₹ 32,025.00	₹ 35,400.00	-₹ 3,375.00
Helper	₹ 244,687.50	₹ 252,000.00	-₹ 7,312.50
carpenter	₹ 343,125.00	₹ 336,000.00	₹ 7,125.00
Mixture with operator	₹ 135,937.50	₹ 140,000.00	-₹ 4,062.50
Vibrator with operator	₹ 81,562.50	₹ 84,000.00	-₹ 2,437.50
Bar Bender	₹ 154,200.00	₹ 174,400.00	-₹ 20,200.00
Helper (Bar Bender)	₹ 96,375.00	₹ 109,000.00	-₹ 12,625.00
Excavator	₹ 34,850.00	₹ 27,200.00	₹ 7,650.00
Piling	₹ 2,287,125.00	₹ 1,909,500.00	₹ 377,625.00

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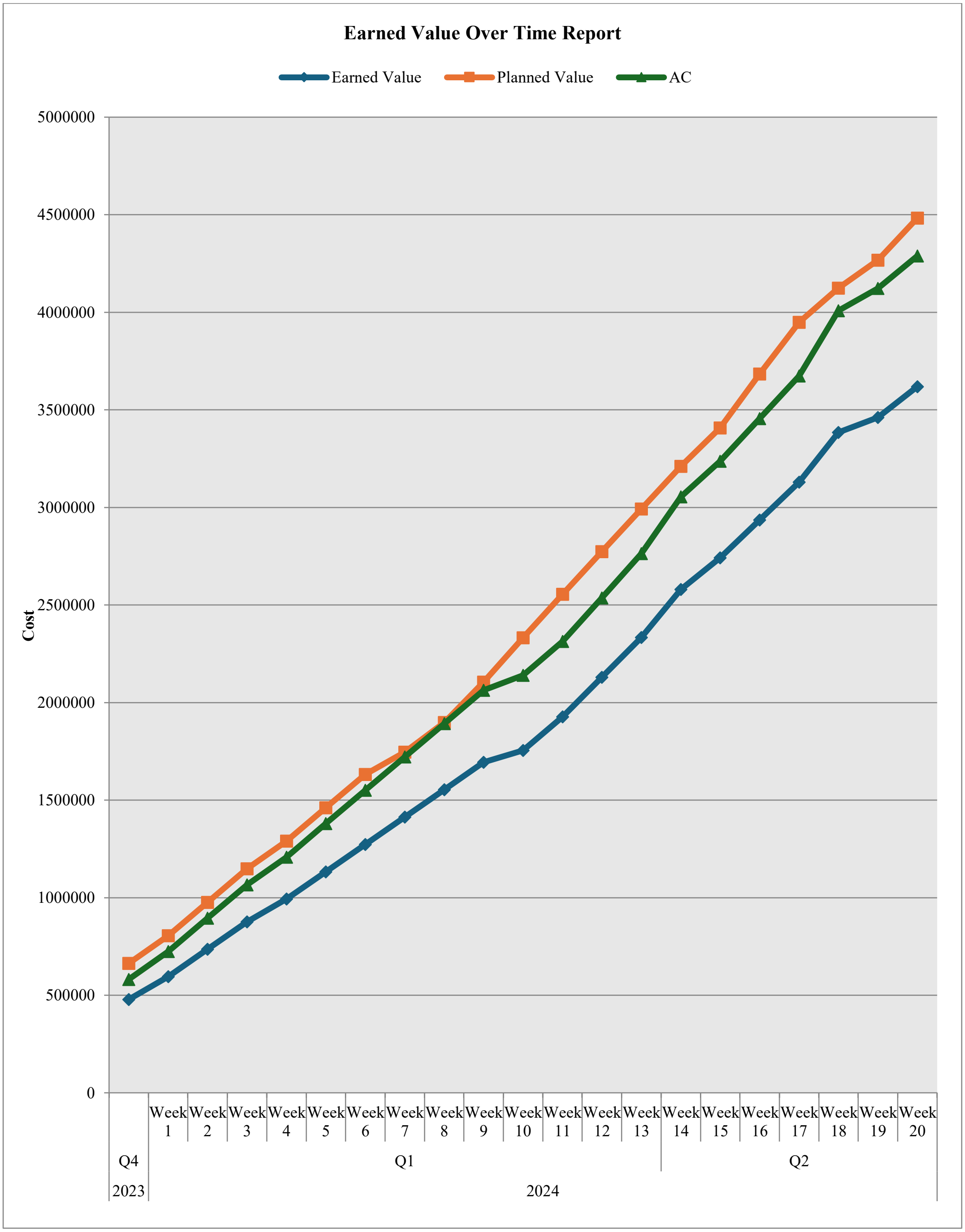
Figure 3: Earned Value Over Time Report



The analysis of labor cost variances in Table 4 presents a cost overrun in several categories. Significant overruns are observed in Piling (₹377,625), Excavator (₹7,650) and Carpenter (₹7,125), while cost savings (underruns) are seen in Bar Bender (₹20,200) and Vibrator with Operator (₹2,437.50).

4.5 Earned value analysis over time

Earned Value Analysis (EVA) is a key project management tool used to assess project performance over time by comparing planned value, earned value and actual cost. The following Figure 3 and Table 5 provide a detailed insight into the project's financial progress, highlighting deviations and trends in cost and schedule performance.

Table 5: Earned Value Data Over Time

Year	Quarter	Week	Earned Value	Planned Value	AC
2023	Q4	Week 48	₹ 7800	₹ 7800	₹ 7800
		Week 49	₹ 80876.92308	₹ 178800	₹ 96862.5
		Week 50	₹ 221184.6154	₹ 349800	₹ 267862.5
		Week 51	₹ 361492.3077	₹ 520800	₹ 438862.5
		Week 52	₹ 478415.3846	₹ 663300	₹ 581362.5
2024	Q1	Week 1	₹ 595338.4615	₹ 805800	₹ 723862.5
		Week 2	₹ 735646.1538	₹ 976800	₹ 894862.5
		Week 3	₹ 875953.8462	₹ 1147800	₹ 1065862.5
		Week 4	₹ 992876.9231	₹ 1290300	₹ 1208362.5
		Week 5	₹ 1133184.615	₹ 1461300	₹ 1379362.5
		Week 6	₹ 1273492.308	₹ 1632300	₹ 1550362.5
		Week 7	₹ 1413800	₹ 1745700	₹ 1721362.5
		Week 8	₹ 1554107.692	₹ 1897500	₹ 1892362.5
		Week 9	₹ 1694415.385	₹ 2105761.538	₹ 2063362.5
		Week 10	₹ 1755000	₹ 2332653.846	₹ 2139525
		Week 11	₹ 1926500	₹ 2555287.5	₹ 2314087.5
		Week 12	₹ 2129328.349	₹ 2773662.5	₹ 2536391.346
		Week 13	₹ 2334005.44	₹ 2992037.5	₹ 2763283.654
	Q2	Week 14	₹ 2579561.077	₹ 3210412.5	₹ 3054065.563
		Week 15	₹ 2741332.08	₹ 3408200	₹ 3236542.003
		Week 16	₹ 2935457.283	₹ 3684180	₹ 3455513.73
		Week 17	₹ 3129582.486	₹ 3949300	₹ 3674485.458
		Week 18	₹ 3385017.03	₹ 4123900	₹ 4007655
		Week 19	₹ 3460500	₹ 4267800	₹ 4122990
		Week 20	₹ 3619566.667	₹ 4483445	₹ 4289190
Grand Total			**₹ 3619566.667**	**₹ 4483445**	**₹ 4289190**

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Figure 3 presents three different S-curves that synthesize the analysis using the Earned Value Management (EVM) approach. The Actual Cost (AC) mostly follows the Earned Value (EV) but exceeds it at several points, indicating cost overruns. The Planned Value (PV) remains higher than EV for most of the project, suggesting slower-than-expected progress. This results in an overall CPI slightly below 1, indicating a cost overrun and an SPI below 1, confirming schedule delays. Figure 3 shows trends of Earned Value, Planned Value and Actual Cost over time. Table 5 presents weekly Earned Value (EV), Planned Value (PV) and Actual Cost (AC) data over multiple weeks, providing insight into the project's financial and schedule performance. This data corresponds to the trends illustrated in Figure 3, where the Earned Value Management (EVM) approach is used to track project progress.

5.0 Performance Analysis and Forecasting

Performance analysis evaluates project progress using key metrics like CPI and SPI, ensuring cost and schedule adherence. Forecasting predicts final costs and completion time through techniques like EAC and ETC. Together, they help with proactive decision-making and risk mitigation for successful project completion.

5.1 Earned value metrics and cost variance analysis

An analysis of key earned value metrics, including Total Cost, Budgeted Cost of Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP) and Budgeted Cost of Work Performed (BCWP) is carried out. These values helps to assess project performance in terms of cost and schedule adherence.

Figure 4: Earned Value Performance Analysis

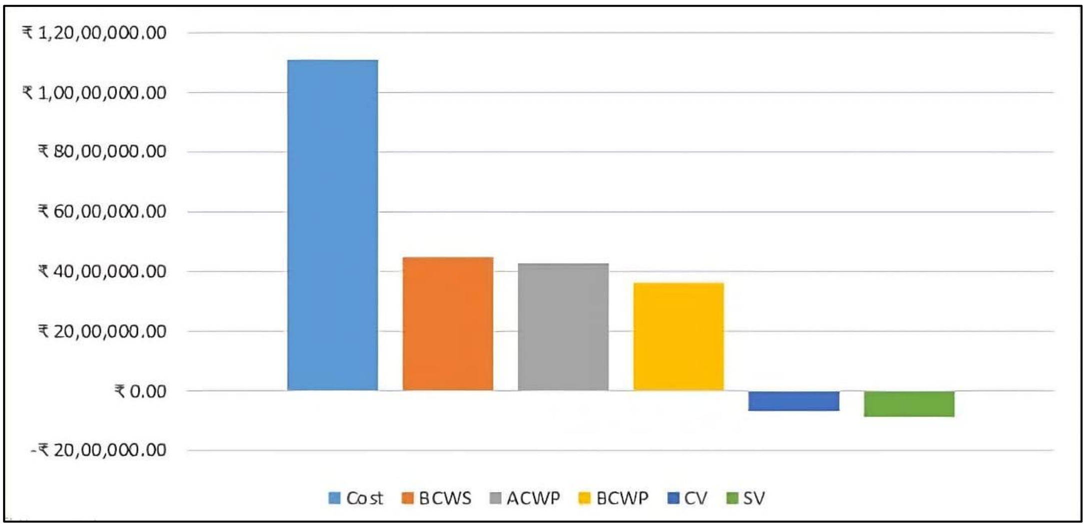

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Figure 4 illustrates the Earned Value Performance Analysis, visually representing key project performance indicators. Table 6 provides the corresponding numerical values, including Total Cost, Budgeted Cost of Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP) and Budgeted Cost of Work Performed (BCWP). Additionally, it includes Cost Variance (CV) and Schedule Variance (SV).

Table 6: Earned Value Performance Metrics

Cost	BCWS	ACWP	BCWP	CV	SV
₹1,10,93,622	₹44,83,445	₹42,89,190	₹36,19,525	-₹6,69,665	-₹8,63,920

According to Table 6 the Cost Variance (CV) is ₹6,69,665, indicating an over-expenditure compared to the work performed. Similarly, the Schedule Variance (SV) is ₹8,63,920, showing a lag in progress relative to the planned schedule. These deviations suggest potential budget overruns and delays, requiring corrective actions for project control.

5.2 Earned value performance metrics and indicators

Table 7 presents key Earned Value performance metrics calculated based on project cost and schedule data. These values, derived using standard EVM formulas, provide insights into cost and schedule variances, efficiency indices and future performance expectations.

Table 7: Earned Value Performance Indicators

Metric	Formula	Calculated Value
Cost Variance (CV)	BCWP – ACWP	- ₹ 669,665.00
Cost Variance % (CV%)	(CV / BCWP) × 100	-18.50%
Schedule Variance (SV)	BCWP – BCWS	- ₹ 863,920.00
Schedule Variance % (SV%)	(SV / BCWS) × 100	-19.27%
Cost Performance Index (CPI)	BCWP / ACWP	0.84
Schedule Performance Index (SPI)	BCWP / BCWS	0.81
Estimate at Completion (EAC)	EAC = BAC / CPI	₹1,31,48,457
Estimate to Complete (ETC)	ETC=EAC−AC	₹88,59,267
Variance at Completion (VAC)	BAC – EAC	- ₹ 1,989,421.14
To-Complete Performance Index (TCPI)	(BAC - BCWP) / (EAC - ACWP)	1.1
Delay in project	Scheduled Finish - Baseline Finish	ays

6.0 Interpretation

1. A negative cost variance indicates that the project is over budget. The project has spent 19% more than the planned budget at this stage.

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2. A negative schedule variance signifies that the project is behind schedule. The work completed so far is 19% less than planned, indicating delays.
3. Since CPI is less than 1, the project is not cost-efficient. A CPI of 0.84 means that for every ₹1 spent, only ₹0.84 worth of work has been completed, indicating cost overruns.
4. Since SPI is below 1, the project is progressing slower than planned. An SPI of 0.81 means that the project is achieving only 81% of the scheduled work at this stage.
5. If the current cost inefficiency continues, the total project cost is expected to be ₹1,31,48,457, which is ₹20,54,835 over budget.
6. To complete the remaining work, an additional ₹88,59,267 is required.
7. The project is expected to exceed its initial budget by ₹1,989,421.14, showing a significant budget overrun.
8. A TCPI value above 1 indicates that the remaining work must be executed more efficiently than the current performance to stay within the budget. The project team needs to improve cost control to meet the planned budget.
9. The project is projected to cost ₹12,742,121.14 at completion, exceeding the original budget estimate. This highlights the need for cost control measures to mitigate overruns.
10. The project has a delay of 25 days compared to the baseline schedule, indicating that corrective measures should be taken to bring the project back on track.

7.0 Causes of Delay

Delays in construction projects are common and can result from multiple factors, affecting timelines, costs, and overall project efficiency. Proper planning and proactive management are essential to minimize disruptions and ensure smooth execution. The key delays identified in this project include:

1. *Inadequate Planning and Scheduling:* Poor scheduling, unrealistic deadlines, and lack of backup plans can disrupt project execution. Inaccurate time estimates for tasks often lead to delays and cost overruns.
2. *Delays in Approvals & Decision-Making:* Construction projects often require permits, design approvals, and regulatory clearances. Delays in approvals or sudden rule changes can significantly slow down the project.
3. *Resource Management Issues:* Shortage of skilled workers, lack of coordination between suppliers and site managers, delays in material delivery, and poor subcontractor management can slow down the project.
4. *Weak Coordination and Communication Among Teams:* When project stakeholders are not aligned and responsibilities are unclear, misunderstandings can arise, delaying decision-making and execution. Poor collaboration between engineers, contractors, and consultants can result in errors, rework, and missed deadlines.
5. *Unpredictable External Factors:* Changes in weather, site conditions, and material costs can disrupt construction work. Factors such as ground conditions, project location, and

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regulatory requirements further impact progress, leading to potential delays and cost increases.

8.0 Conclusions

This study evaluates the performance of a G+8 residential construction project using Microsoft Project and Earned Value Analysis (EVA). The analysis reveals that the project is currently 25 days behind schedule and has exceeded its planned budget by ₹1,989,421, highlighting inefficiencies in both time and cost management. At 43% completion, performance metrics indicate the following:

- The Cost Performance Index (CPI) of 0.84 indicates a 16% cost overrun, meaning only 84% of the value is realized for every ₹1 spent.
- The Schedule Performance Index (SPI) of 0.81 shows the project is progressing at 81% of the planned rate, resulting in a 19% delay.
- The Estimate at Completion (EAC) is ₹1,31,48,457, which is 18.5% over the initial budget, amounting to an overrun of ₹20,54,835 if current inefficiencies continue.
- The To-Complete Performance Index (TCPI) of 1.1 means the remaining work must be done 10% more efficiently to stay within budget.
- Given these findings, immediate corrective actions are necessary to control costs, improve efficiency, and reduce further delays.
- Regular progress tracking, resource optimization, and early risk mitigation strategies will help realign the project with its planned objectives and ensure successful completion.

9.0 Recommendations for Reducing Construction Delays

To ensure timely project completion and minimize disruptions, the following practices should be followed:

1. *Detailed Planning and Scheduling:* A well-structured project timeline with realistic deadlines helps prevent delays. Including buffer time for unexpected issues ensures flexibility.
2. *Early Permit Approvals:* Securing all necessary approvals from local authorities in the early stages avoids unnecessary stoppages during construction.
3. *Proper Resource Allocation:* Ensuring the availability of labor, materials, and equipment at the right time helps maintain steady progress.
4. *Clear Communication and Coordination:* Regular site meetings and clear instructions among team members, subcontractors, and suppliers improve efficiency and reduce misunderstandings.
5. *Ongoing Progress Tracking:* Monitoring the project through periodic reviews helps identify potential delays early, allowing for corrective actions.

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6. *Risk Management Strategies:* Identifying potential risks, such as weather disruptions or material shortages, and preparing contingency plans can help mitigate delays.
7. *Workforce Skill Development:* Providing training for workers and supervisors ensures that tasks are completed correctly and efficiently.
8. *Use of Technology:* Implementing project management tools for scheduling, documentation, and communication can improve overall efficiency.

By adopting these common construction management practices, projects can be completed on time, within budget, and with minimal disruptions.

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