

# Application of Earned Value Management for high rise building project for performance evaluation with respect to cost and schedule

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## ABSTRACT

*Cost overrun is a prevalent challenge in the construction industry, with a significant number of projects exceeding their initial budget estimates. This paper explores the causes, classification, and impact of cost overrun in construction projects. Factors such as ineffective project management, poor planning, inaccurate cost estimation, labor shortages, material price fluctuations, and external factors like unpredictable weather and government policies contribute to these overruns. Despite advancements in project management tools, cost overruns continue to plague the industry due to mismanagement, inefficiencies, and unforeseen circumstances. Various evaluation methods, including Earned Value Analysis (EVA), are highlighted to assess project performance, identify cost variances, and implement proactive measures to minimize overruns. This study emphasizes the need for better planning, efficient cost control mechanisms, and stakeholder collaboration to mitigate the risk of cost overruns and improve project outcomes.*

**Keywords:** - Cost Overrun, Project Management, Cost Estimation, Earned Value Analysis (EVA)

## 1. INTRODUCTION

Construction projects are often measured by metrics like cost and time, which help evaluate performance against the project baseline. However, delays in construction are usually tied to unplanned costs. Among the four main constraints of construction—quality, scope, time, and cost—cost performance is considered the most critical. Research shows that only 13% of construction projects in Asian countries stay within budget, with actual costs exceeding estimates by an average of 28% (Huda Mahmood, 2021). This pattern is consistent globally, affecting both developed and developing nations, including small island states. Despite advancements in technology and project management practices, accurately estimating costs and sticking to the budget remains one of the biggest challenges in the construction industry. When costs spiral out of control, it creates financial strain, forcing companies to reallocate funds from planned projects to cover overruns, leaving many projects incomplete and disrupting economic activities [1].

In India specifically, of 555 projects worth Rs 150 crore each, at least 179 experienced cost overruns amounting to Rs 1.23 lakh crore. These overruns not only harm organizational profitability but also delay or halt economic development. Despite the widespread knowledge of cost overruns, their root causes haven't been thoroughly explored, leaving room for further research into this issue. High-rise construction projects in India add another layer of complexity to this challenge. According to the International Building Code (IBC), high-rises are buildings taller than 75 feet. These projects, with their intricate designs and advanced systems, are more prone to coordination and communication problems, which drive up costs. The demand for high-rises has skyrocketed in India, with over 52% of housing projects launched in 2019 across the top seven cities classified as high-rises [2].

To achieve better economic outcomes in construction projects, it's essential to identify and understand the factors that lead to cost overruns. By addressing these factors proactively, professionals can implement strategies to control unaccounted costs and avoid future budget overruns. This study focuses on analyzing the most common causes of cost overruns in Indian high-rise construction projects. The insights gained can help industry professionals refine their cost management strategies and improve overall project performance. The construction sector plays a crucial role in India's economy, driving growth across various industries. As of the fourth quarter of 2020, the sector was valued at over 2.7 trillion Indian rupees, making it a vital indicator of the country's economic health. By addressing the issue of cost overruns, the industry can not only achieve better project outcomes but also contribute more effectively to India's development [3].

High-rise residential and commercial projects are inherently complex and susceptible to significant cost

overruns and schedule delays due to factors like design changes, resource availability, and site constraints. Traditional project monitoring, which often compares planned expenditure to actual spending, fails to account for the actual work completed. This is where Earned Value Management (EVM) provides a distinct advantage. By introducing the concept of "earned value" (the budgeted cost of work actually performed), EVM creates a "triangulated" view against the planned value and actual costs, enabling a more accurate diagnosis of project status [4].

## **2. CAUSES OF COST OVERRUN IN CONSTRUCTION PROJECTS**

This comprehensive document outlines various causes of cost overrun in construction projects. Here's a summary of the key points from each section:

### **2.1 General Causes of Cost Overruns**

Cost overruns are a persistent issue in the construction industry, with the majority of projects exceeding their budgets. Studies reveal that 9 out of 10 construction projects face cost overruns, with variations ranging from 5% to over 100%, depending on factors like project location, scope, and management efficiency. These overruns often stem from inadequate project preparation, poor cost control systems, increased material and labor costs, unexpected weather conditions, and delays in delivery. Despite advancements in project management methods and tools, these challenges remain prevalent due to the dynamic and multidisciplinary nature of construction projects.

### **2.2 Design and Contract-Related Factors**

The design phase plays a critical role in project cost performance, as issues here can cascade into significant financial impacts during construction. Frequent design changes, incomplete designs, inadequate pre-construction studies, and poor coordination during the design stage are common causes of cost overruns. Many of these issues are avoidable with proper planning, communication, and sufficient time allocated for design and contract preparation.

### **2.3 Estimation-Related Factors**

Accurate estimation of costs and timelines is essential for successful project execution. Problems such as underestimating project duration, inaccurate quantity take-offs, using inappropriate estimation methods, and insufficient cost data often lead to cost overruns. Additionally, the experience and skill level of estimators are crucial in ensuring reliable pre-tender cost estimates. Without accurate estimates, project funding and scheduling become unreliable, leading to financial strain.

### **2.4 Planning and Scheduling Factor**

Effective planning is a cornerstone of successful project execution. It involves defining objectives, estimating timelines, allocating resources, and creating realistic schedules. Inadequate planning, poor scheduling, and insufficient monitoring during the pre-construction and construction phases frequently lead to delays and cost increases. Emphasizing operational planning over reactive monitoring is essential for minimizing these issues.

### **2.5 Project Management Factors**

Project management significantly influences cost performance, as construction projects require the coordination of large teams, equipment, and resources. Poor site management, lack of supervision, inadequate contractor performance, and ineffective cost control systems are common contributors to cost overruns. Strong leadership and effective project management practices, including proper contract management and financial oversight, are critical for avoiding cost escalation.

### **2.6 Labor-Related Factors**

Labor-related challenges such as shortages of skilled workers, high labor costs, and low productivity are frequent causes of cost overruns. As the workforce ages, a lack of skilled replacements exacerbates these issues. Additionally, poor relationships between management and workers or subcontractors can further reduce efficiency, increasing project costs.

### **2.7 Financial Factors**

Financial constraints are a major cause of cost overruns in construction projects. Delays in payments, insufficient funding, inconsistent cash flows, and economic instability can disrupt project progress and increase costs. Other factors, such as fluctuating foreign currency exchange rates and inflation, further compound financial challenges, making it difficult to stay within budget.

### **2.8 Material and Machinery Factors**

Materials and machinery costs represent a significant portion of construction expenses. Fluctuations in material prices, inflation, high machinery costs, and monopolistic practices by suppliers often result in cost overruns. Delays in material delivery and supply chain disruptions also contribute to higher project costs, especially in regions with volatile economic conditions.

**2.9 Construction-Related Factors**

The construction phase is often fraught with challenges, including delays, scope changes, and errors that result in rework. Poor construction practices, lack of contractor experience, and insufficient supervision can escalate costs. Additionally, changes in material specifications, transport costs, and conflicts among project participants further increase financial pressure during this stage.

**2.10 Communication Factors**

Effective communication is vital in construction projects, as they involve numerous stakeholders. Poor coordination and communication among key parties can lead to misunderstandings, delays, and conflicts, all of which contribute to cost overruns. Ensuring clear, consistent communication among all stakeholders is essential to avoid unnecessary delays and costs.

**2.11 External Factors**

External factors such as unpredictable weather, government regulations, political instability, and corruption significantly impact project costs. Natural disasters, delays in land acquisition, and emergency work also contribute to cost escalation. These factors, often beyond the control of project teams, highlight the need for robust risk management and contingency planning.

**Table 1:** Contributors to Cost Overruns in Project

<b>Factor</b>	<b>Approximate Impact</b>
Design errors	38%
Labour productivity	40–60%
Material price fluctuation	22%
Communication issues	30%
Rework	5–12%

**3. COST OVERRUN EVALUATION METHODS**

Evaluating cost overruns involves identifying the extent, causes, and impacts of financial discrepancies in construction projects. One common approach is variance analysis, which compares actual costs against baseline estimates to determine deviations. Cost performance indices (CPI), derived from Earned Value Management (EVM), are widely used to evaluate cost efficiency by comparing the budgeted cost of work performed (BCWP) with the actual cost of work performed (ACWP). Trend analysis helps identify patterns of cost deviations over time, allowing project managers to anticipate potential overruns early. Root cause analysis (RCA) is another critical method, focusing on identifying the underlying reasons for cost deviations, such as design errors, scheduling issues, or procurement delays. Benchmarking, which involves comparing a project’s performance against similar projects, provides insights into cost discrepancies and industry standards. Simulation techniques like Monte Carlo analysis evaluate uncertainties by modeling various project scenarios, helping to predict cost overrun risks. Lastly, sensitivity analysis examines the impact of changes in project variables, such as material prices or labor costs, on overall budgets. These evaluation methods enable project managers to analyze cost overruns comprehensively and develop mitigation strategies to improve cost performance in future projects.

**3.1 Earned Value Analysis**

Earned Value Analysis (EVA) is a project management technique used to measure project performance by integrating scope, cost, and schedule. It provides a quantitative framework for assessing whether a project is on track regarding budget and schedule. EVA involves three key metrics: Planned Value (PV), the budgeted cost of the work scheduled to be completed by a specific time; Earned Value (EV), the budgeted cost of the work actually completed; and Actual Cost (AC), the actual expenditure incurred to complete the work. Using these metrics, project managers calculate performance indicators such as the Cost Performance Index (CPI) ( $EV/AC$ ) to evaluate cost efficiency and the Schedule Performance Index (SPI) ( $EV/PV$ ) to determine schedule adherence. Variance metrics like Cost Variance (CV) ( $EV - AC$ ) and Schedule Variance (SV) ( $EV - PV$ ) highlight the magnitude of cost and schedule deviations. By integrating these metrics, EVA helps project managers predict the final project cost using the Estimate at Completion (EAC) formula and assess the time required for completion. EVA not only provides a snapshot of project health but also facilitates proactive decision-making by identifying potential cost overruns or delays early. It is a vital tool for maintaining control over project performance and ensuring successful delivery. Earned value is a technique for measuring project performance according to project cost and schedule. The comparison between budgeted and actual performance is performed. There are three earned value parameters as shown below.

**Planned Value (PV):** It is the cost of the project according to the schedule of the project. It is also called the Budgeted Cost of Work Schedule (BCWS).

**Earned Value (EV):** It is the Budgeted Cost of the Work Performed (BCWP) till date. It is the cumulative budgeted cost incurred in activities that have been completed on the due date.

**Actual Cost (AC):** It is the actual cost that has been spent on the project to date. It is also called as actual Cost of Work Performed (ACWP).

The variances are used to check the deflection or deviation of the project from the original schedule. It is also used to analyze the extent and cause of the delays in work or tasks of the project.

Following the two variances:

**Cost Variances (CV):** It is used to check the difference between the proposed planned project and the present project on a specific date. It shows the variation of the project in the form of cost. The formula used for calculating cost variances is  $\text{Cost Variance} = \text{Earned Value} - \text{Actual Cost}$

**Schedule Variance (SV):** It is used to examine the deflection of the present project from the planned project. If considerable change appears than the project objectives must be revised. The formula for calculating the schedule variance is  $\text{Schedule Variance} = \text{Earned Value} - \text{Planned Value}$

**Schedule Performance Index (SPI):** SPI can be used to estimate the projected time to complete the project. It is calculated as follows,

$\text{SPI} = \text{Earned Value} / \text{Planned Value}$ . SPI = 1 means the project is on Schedule

SPI < 1 means the project is behind Schedule. SPI > 1 means the project is ahead of Schedule

**Cost Performance Index (CPI):** CPI can be used to estimate the project cost to complete the project based on performance to date. It is calculated as follows,

$\text{CPI} = \text{Earned Value} / \text{Actual Cost}$

CPI = 1 means Planned and Actual costs are the same

CPI < 1 means the project is under budget. CPI > 1 means the project is over Budget.

**Estimate at Completion (EAC):** The Estimate at Completion is the actual cost to date plus an objective estimate of costs for remaining authorized work. The most common is

$\text{EAC} = \text{Actual cost} + \text{Estimate to Complete}$ .

Indicator Value	Interpretation	Approximate Occurrence in Construction Projects
SPI = 1	Project on schedule	20–30% of projects
SPI < 1	Project behind schedule	70–80% of projects
CPI = 1	Cost as planned	25–35% of projects
CPI < 1	Cost overrun	60–65% of projects
CPI > 1	Cost saving	5–10% of projects

#### 4. CHALLENGES IN IMPLEMENTATION

Despite its proven benefits, the adoption of EVM faces barriers. Research in the Ethiopian construction industry identified "poor managers' commitment," "lack of team member support," and a shortage of proper training as primary hindrances. This is echoed in the Indian context, where EVM is often not practiced due to a "lack of understanding of the importance" among project teams. The successful application of EVM requires a cultural shift towards data-driven decision-making and a disciplined approach to defining the Work Breakdown Structure (WBS) from the project's outset.

#### 5. CONCLUSIONS

Cost overrun is one of the most critical issues in the construction industry, affecting project timelines, budgets, and overall performance. This paper identified numerous causes of cost overrun, categorized into internal and external factors, including design flaws, inaccurate estimation, poor project planning, ineffective management, and external influences such as inflation and political instability. The findings highlight the importance of early-stage planning, accurate estimation techniques, and robust project management practices to minimize cost overruns. Methods like Earned Value Analysis (EVA) can provide valuable insights into project performance by integrating scope, cost, and schedule, enabling stakeholders to make timely adjustments and improve outcomes. Addressing the causes of cost overruns requires a coordinated effort from project owners, contractors, consultants, and policymakers to ensure better resource management and decision-making throughout the project lifecycle. By adopting proactive strategies and leveraging effective evaluation methods, the construction industry can mitigate the impacts of cost overruns and achieve greater efficiency and sustainability in project delivery.

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