

Mitigation of Risks Arise Due to Cost Overrun and Time Delay by Using RII and MATLAB for Public Buildings

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ABSTRACT

Cost overruns and time delays remain persistent and critical issues in the global construction industry, with public building projects in India being no exception. These challenges often result from inaccurate cost estimations, mismanagement, and project-specific or region-specific socio-economic and political factors. If not effectively mitigated, they may lead to severe consequences such as disputes, financial losses, or even project termination. This research investigates the root causes and impacts of cost and time overruns in public building projects, focusing on the cities of Amravati, Akola, and Nagpur in Maharashtra, India. The study aims to analyze the primary factors contributing to these overruns by leveraging the Relative Importance Index (RII) method and validating the results through MATLAB-based simulation and analysis. A comparative evaluation of project cost control procedures and time-cost overrun theories is conducted to understand their practical applications and gaps. The research also highlights the similarities and differences in risk factors across different urban regions and proposes strategic risk mitigation approaches tailored to the Indian construction environment.

Keywords:-Cost overrun, Time delay, Relative Importance Index (RII), MATLAB.

1. INTRODUCTION

The construction industry plays a crucial role in the economic growth of countries worldwide, as it supports infrastructure development and stimulates allied sectors. In India, the construction sector serves as a key measure of national development by generating substantial investment opportunities across multiple industries. During the financial year 2023–24, the sector recorded a strong growth rate of approximately 10.7%, reflecting its expanding contribution to the economy.[1] The Indian construction industry is highly fragmented in nature. A limited number of large firms operate across multiple construction segments, while medium-sized enterprises focus on specialized or niche areas. In addition, a large proportion of work is executed by small and medium contractors who function primarily as subcontractors at the project execution level. As of 2011, India had more than 500 construction equipment manufacturing companies. [11] Owing to its labour-intensive nature, the construction sector provides employment to over 35 million people, including both direct and indirect job opportunities. [5]

The construction industry is a vital component of the national economy and significantly influences the productivity and performance of other sectors. Investments in manufacturing, agriculture, and service industries cannot be effectively realized without the availability of adequate infrastructure. [6] The construction sector possesses several distinct characteristics that differentiate it from other industries. Project conditions often become more complex during execution than initially anticipated during the planning and design stages, leading to increases in both cost and project duration. Moreover, the development of large-scale infrastructure facilities typically requires long completion periods and substantial financial investment. [9]

Project success is determined by multiple factors, with the most critical being the completion of work within the planned budget and stipulated time while maintaining the required quality standards. In addition, ensuring safe working conditions and minimizing health and safety risks are essential aspects of successful project delivery. [16]

A. Problem Statement

Delays and cost overruns are persistent challenges faced by the building construction industry worldwide. Although the nature of these issues is similar across countries, their underlying causes vary depending on political, economic, and cultural conditions.[7] Inadequate cost estimation, ineffective planning, and unforeseen

project conditions often contribute to schedule delays and budget overruns. If these factors are not properly addressed, they may ultimately result in project suspension or termination. Time overrun in building construction refers to the failure to complete a project within the planned or contractually agreed schedule, leading to delayed progress or late project completion by the contractor.[13] This research aims to examine the similarities and differences between project cost control practices and theoretical frameworks related to cost and time overruns in the construction industry. Furthermore, the study seeks to identify the major factors contributing to cost and time overruns in public building projects in Amravati, Akola, and Nagpur. The findings are expected to provide insights into improving efficiency in the Indian construction industry and enhancing its ability to deliver projects at internationally acceptable cost and time standards.[17]

B. Cost Overrun

Cost overrun, commonly known as budget overrun, arises when the final expenditure of a construction project surpasses the originally approved or estimated budget.[3] This issue is prevalent across the construction industry and has a significant impact on project performance, stakeholder confidence, and overall financial viability. Cost overruns may occur due to various technical, managerial, economic, and external influences.[9] Common contributing factors include inaccurate cost estimation during the planning stage, frequent design modifications, escalation in material and labor prices, inefficient project management practices, delays in decision-making, inadequate contract administration, and unforeseen site conditions. In addition, external factors such as regulatory changes, market fluctuations, and adverse weather conditions can further intensify cost overruns [10]:

1. Poor Cost Estimation

- Inaccurate or insufficient cost estimates prepared during the initial planning stage[1]
- Excessive optimism in forecasting material prices, labor costs, and productivity rates[5]
- Absence of comprehensive feasibility studies and detailed pre-project analysis[6]

2. Design Changes and Scope Creep

- Repeated modifications to design details during the construction phase[8]
- Additional requirements or alterations requested by the client after project initiation[23]
- Inadequate or unclear definition of project scope during the planning stage[28]

3. Delay in Project Execution

- Schedule slippages caused by ineffective planning and improper allocation of resources[17]
- Construction delays resulting from adverse weather conditions[21]
- Time losses due to late approvals, clearances, or permit processing[34]

4. Inflation and Price Fluctuations

- Unexpected escalation in the cost of key construction materials such as steel, cement, and fuel[26]
- Fluctuations in currency exchange rates affecting the cost of imported materials[5]

5. Inefficient Project Management

- Ineffective coordination and communication among project stakeholders[10]
- Delays caused by slow or inefficient decision-making processes[33]
- Absence of systematic risk identification, assessment, and mitigation measures[37]

6. Contractor-Related Issues

- Insufficient technical expertise or limited experience of contractors in executing similar projects[26]
- Unrealistically low bidding to secure contracts, often resulting in subsequent cost escalations during execution[28]
- Labor-related issues, including disputes, absenteeism, or shortage of skilled manpower[23]

7. External Factors

- Political uncertainty or changes in government policies affecting project execution[22]
- Modifications in legal frameworks, regulations, or compliance requirements during the project lifecycle[29]
- Unanticipated site conditions such as problematic soil characteristics or unknown underground services[31]

2. DELAY OR TIME OVERRUN

In building construction projects, delay or time overrun refers to the failure to achieve project milestones or complete the work within the planned baseline schedule or the contractually agreed duration. In simple terms, it represents the difference between the actual time taken to complete a project and the originally estimated project duration. Time overruns are most commonly observed during the construction phase, where numerous unanticipated conditions and operational challenges may arise. [40]

Although the term delay is widely used in construction contracts, it does not have a single precise technical definition. Broadly, it encompasses any event, condition, or circumstance that hinders the commencement,

progress, or completion of project activities, thereby extending the overall project duration.[38] Delays are often linked to both schedule slippage and increased project costs, making them a recurring issue in construction projects worldwide. Understanding the different categories of delays is essential for effective project performance evaluation and for developing appropriate mitigation measures.[26]

1. Excusable Delay

Excusable delays are those that occur due to unforeseen circumstances beyond the reasonable control of both the contractor and the client. Such delays are generally recognized under contract provisions and may entitle the contractor to an extension of time without penalties. Excusable delays are commonly classified into the following categories:

- **Compensable Excusable Delays** – In this category, the contractor is eligible for both an extension of time and financial compensation. Such delays generally arise from circumstances attributable to the client, including delayed approvals, changes in design, late issuance of drawings, or failure to provide timely access to the construction site[18] [21].
 - **Non-Compensable Excusable Delays** – Under this type, the contractor is granted an extension of time without entitlement to additional payment. These delays are usually caused by factors beyond the control of both parties, such as extreme weather events, natural disasters, or other force majeure conditions. [17] [31].
- In both cases, the delays are regarded as legitimate; however, the contractor's entitlement to compensation is governed by the contract conditions and the responsibility for the delay. [22] [32].

2. Non-Excusable Delay

Non-excusable delays occur due to factors that are foreseeable and within the contractor's control. These delays typically result from inadequate planning, poor site management, or shortages of labor and materials. In such cases, the contractor is neither entitled to an extension of time nor financial compensation. Furthermore, if these delays cause the project to finish later than the agreed completion date, the contractor may be held responsible for liquidated damages as specified in the contract.[1] [5] [9] [11]

3. Concurrent Delay

Concurrent delays arise when two or more delays occur at the same time or during overlapping periods, usually involving both the contractor and the client. These situations make it challenging to determine responsibility, as multiple parties contribute to the delay. Resolving concurrent delays typically requires detailed analysis of the project schedule, including critical path assessment and, in some cases, forensic delay investigation. Concurrent delays may affect both critical and non-critical project activities, impacting the overall timeline and completion date.[11] [8] [26] [24]

4. Compensable Delay

Compensable delays are primarily caused by the client or project owner, and the contractor is generally entitled to both an extension of time and financial compensation. Typical examples include:

- Incomplete, inaccurate, or unclear design documents[20]
- Late approvals or delayed responses to RFIs (Requests for Information) [11]
- Changes in project scope, specifications, or materials[16]
- Delayed handover of the construction site[13]

Most construction contracts include specific clauses addressing such situations, allowing the contractor to claim additional costs and time extensions resulting from these delays.

5. Critical and Non-Critical Delays

- **Critical Delay** – A critical delay is one that directly affects the project's overall completion date. Such delays typically occur along the critical path of the project schedule and often justify claims for time extensions and, in some cases, financial compensation. [26]
- **Non-Critical Delay** – Non-critical delays impact activities that have available float or slack time and, therefore, do not affect the final project delivery date. While these delays may influence resource allocation, subcontractor scheduling, or interim milestones, they generally do not warrant extensions of time or compensation. [24]

A. Causes of Delay and Cost Overruns

In the construction industry, especially in public building projects, delays and cost overruns are recurring challenges that can significantly undermine project success. These issues not only hinder timely project delivery but also erode stakeholder confidence, strain financial resources, and may compromise the quality of work. Identifying and understanding the underlying causes of such problems is crucial for effective risk management and the implementation of mitigation strategies. The causes of delays and cost overruns can be broadly

classified into five major categories: Client-related factors, Contractor-related factors, Consultant-related factors, External factors, and Project-specific issues. [22] [8]

Table 1 – Summary of causes of delays & cost Overruns as retrieved from different literature review

Sr. No	Causes of Delay and Cost Overrun
Client-Related Causes	
	These are issues caused by the project owner (client), including interference, slow decisions, financial constraints, or changes during construction.
1	Unrealistic contract duration imposed by the owner
2	Owner or user interference
3	Delay or slowness in decision making
4	Financial difficulties of the owner and the contractor
5	Inadequate project formulation; and midstream changes in scope and volume of work
6	Design changes, and delay in approving the changes
7	Delay in progress payment; site mobilization; and in obtaining permits from municipality
8	Change in orders by the owner during construction
Contractor-Related Causes	
	These include poor management, labor issues, material handling problems, equipment shortages, and planning failures caused by the contractor.
1	Poor material handling on site
2	Delay of material and equipment delivery
3	Strikes by site personnel
4	Low productivity of labour, and equipment
5	Poor contract management; and poor project management
6	Lack of cost and monitoring planning; poor cost control
7	Equipment and tool shortage on site
8	Unskilled operators or workforce and lack of experience for the workforce and contractors
9	Poor or lack of communication and coordination between parties
10	Poor site management and supervision
11	Deficient estimation of cost
12	Shortage of manpower, and insufficient number of staff
13	Non-performance of main contractors, subcontractors and nominated suppliers
14	Re-work due to errors during construction
15	Ineffective planning and scheduling of project
Consultant-Related Causes	
	Issues originating from the design team or supervising consultants, such as design errors or delayed approvals.
1	Absence of consultants' site staff, and the relationship between management and labour
2	Omission and errors in the Bill of Quantity
3	Slowness or delay in giving instruction
4	Delay of material approval by consultant
5	Variation at the design stage
6	Incomplete design and estimate at the time of tender, as well as lack of design details and specifications
7	Improvement of standard drawing during construction stage
8	Design changes, and delay in approving the changes (also client-related)
9	Design documentation error and discrepancy
10	Design error and inappropriate design solution
External Factors	
	These include external economic, political, and environmental conditions beyond the control of the project stakeholders.
1	Act of God (weather)
2	Government interference
3	Political instability
4	Price fluctuation
5	Poor economic condition
6	Shortage of material in the market
7	Problems with neighbours
8	Corruption and bureaucracy in government

Project-Specific Issues	
	These are challenges related to the nature, complexity, and risk profile of the specific construction project.
1	Dispute on site
2	Large and complex projects
3	Poor site condition
4	Inadequate project formulation; and midstream changes in scope and volume of work (also client-related)
5	Risks and uncertainties associated with projects, as well as lack of project risk analysis
6	Inaccurate evaluation of projects time/duration against the project complexity

3. QUESTIONNAIRE DESIGN

A structured questionnaire survey will be conducted to collect data from active construction sites. The questionnaire will be carefully designed to capture information regarding day-to-day project activities related to cost and time, and to assess how these activities are affected by various risk factors. The survey will target key project stakeholders, including project managers, engineers, site supervisors, and contractors, to obtain comprehensive insights from multiple perspectives within the construction process.

A. Study Area

To achieve comprehensive and regionally representative data, the study will focus on three major urban centers in Maharashtra, India, which are recognized for their high levels of public construction activity:

- Study Area 1 – Amravati
- Study Area 2 – Akola
- Study Area 3 – Nagpur

From each of the selected urban centers, 10 construction sites will be chosen, resulting in a total of 30 projects for the study. The site selection will aim to include a variety of project sizes, types, and stages of development, thereby ensuring that the collected data is diverse, representative, and reflective of the broader public construction sector:

B. Sample Calculation- Amravati

Table 2 – Total no. of Contractors, Site Engineers, Supervisors for Amravati

Site Name	Total
Thete Associates	9
V.P. Mehare Constructions	11
Shankara Constructions	8
Quazi Constructions	11
Rajmata Jijau Builder and Developer Constructions	11
Parag Lakhekar Builders and Associates	9
Reforms Constructions Pvt. Ltd.	13
Rachayati Realtors and Developers Pvt. Ltd.	9
Anshuman Builder Pvt. Ltd.	9
Shanti Kisan Associates	10
Total	100

- Precision (e) = $\pm 5\% = 0.05$
- Proportion (p) = 0.5 (maximum variability, conservative estimate)
- So, $q = 1 - p = 0.5$

Now let's say we want 95% confidence, and at least 5 percent (+) plus or minus (-) precision. A 95 % confidence level gives us Z values of 1.96, per the normal tables, so we get

$$n_0 = \frac{((1.96)^2 (0.5) (0.5))}{(0.05)^2} = 384.16$$

If the population we're studying is small, we can modify the sample size we calculated in the above formula by using this equation:

$$\text{Sample size} = \frac{384.16}{(1 + (384.16 - 1 / 100))} = 79.5$$

Required sample size = Approx. 80 respondents

C. Sample Calculation- Akola

Table 3 - Total no. of Contractors, Site Engineers, Supervisors for Akola

Site Name	Total
KBC Construction	12
Surekha Construction and Designs	14
Mate Construction	9

Suraj Construction	12
Mohata Builders and Developers	10
Amrut and Associate	13
Soham Infra.	11
Kiwi Constructions	13
Gauranga Constructions and Consultancy Services	13
Sai Constructions and Developer	13
Total	120

- Population (N) = 120
- Confidence Level = 95% (Z = 1.96)
- Precision (e) = $\pm 5\%$ = 0.05
- Proportion (p) = 0.5 (maximum variability, conservative estimate)
- So, $q = 1 - p = 0.5$

Now let's say we want 95% confidence, and at least 5 percent (+) plus or minus (-) precision. A 95 % confidence level gives us Z values of 1.96, per the normal tables, so we get

$$n_0 = ((1.96)^2 (0.5) (0.5)) / (0.05)^2 = 384.16$$

If the population we're studying is small, we can modify the sample size we calculated in the above formula by using this equation:

$$\text{Sample size} = 384.16 / (1 + (384.16 - 1 / 120)) = 91.6$$

Required sample size = Approx. 92 respondents

D. Sample Calculation- Nagpur

Table 3 - Total no. of Contractors, Site Engineers, Supervisors for Akola

Site Name	Total
Rachana Constructions	14
Rising Phoenix Real Estate and Construction	14
Om Shivam Buildcon Pvt. Ltd.	16
Dubey Infrastructure	12
Hitesh Infrastructure	11
A Plus (A+) Construction	14
Shubh Shiv Constructions	11
Puranik Brothers	14
Hitesh Constructions	13
Shreeraj Engineers and Builders	16
Total	135

- Population (N) = 135
- Confidence Level = 95% (Z = 1.96)
- Precision (e) = $\pm 5\%$ = 0.05
- Proportion (p) = 0.5 (maximum variability, conservative estimate)
- So, $q = 1 - p = 0.5$

Now let's say we want 95% confidence, and at least 5 percent (+) plus or minus (-) precision. A 95 % confidence level gives us Z values of 1.96, per the normal tables, so we get

$$n_0 = ((1.96)^2 (0.5) (0.5)) / (0.05)^2 = 384.16$$

If the population we're studying is small, we can modify the sample size we calculated in the above formula by using this equation:

$$\text{Sample size} = 384.16 / (1 + (384.16 - 1 / 135)) = 100.13$$

Required sample size = Approx. 100 respondents

4. CONCLUSION

The review of literature indicates that cost overruns and time delays remain persistent challenges in building construction projects, particularly in developing countries such as India. These issues not only impede successful project completion but also lead to disputes among stakeholders and reduce overall efficiency in the construction sector.

Previous studies have identified several key contributing factors, including inadequate planning, design modifications, insufficient project management, financial constraints, and external risks such as inflation and political instability. Many of these studies have primarily relied on questionnaire-based surveys, employing

tools like the Relative Importance Index (RII) to rank critical causes of delays and cost overruns. However, most research has been limited to the perspective of either the client or the contractor, and few studies have utilized advanced analytical methods for predictive modeling and simulation.

The literature review also highlights a significant research gap: a lack of region-specific, multi-stakeholder studies that combine quantitative methods to assess and simulate the impact of various risk factors. The present study aims to address this gap by involving a broader range of stakeholders, applying tools such as MATLAB for analysis, and focusing on three major urban centers in Maharashtra—Amravati, Akola, and Nagpur.

By addressing these gaps, the research seeks to provide actionable insights and strategic recommendations for mitigating cost and time overruns in public building projects. Enhancing planning, communication, stakeholder coordination, and early risk identification can ultimately improve the efficiency, timeliness, and sustainability of project delivery in the Indian construction industry.

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