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An investigation study on residential buildings for cost overrun

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Construction projects are now widely recognized as being among the most important factors contributing to the overall economic development of a nation. When delays occur in these construction projects, however, both the overall progress of the projects and their profitability are affected. In this investigation, a literature review and a questionnaire survey were used to find the most important factors that cause delays in the Indian construction industry. The survey participants included clients, contractors, and structural designers. The research disclosed a total of twelve different reasons for the cost overrun. After that, the causes of these delays were ranked using three different methods: a frequency index, a severity index, and an importance index that took into account the degree of severity and the frequency with which they occurred. The responses are utilized in the procedure, which is carried out through Questionnaire. Reliability of questionnaires is carried out with the help of the Cronbach`s Alpha value, which is found to be greater than 0.70, which measures the internal consistency of values. The case study is carried out in Chennai, a metropolitan city, with the purpose of doing more research into the primary factors contributing to cost overruns. It is envisaged that the findings of this study would help in the identification of factors and causes in the building projects of India and allow the stakeholders in these projects to take efforts to prevent the incidence of these delays.

Keywords Cost overrun, Frequency Index, Severity Index, Importance Index, Ranking, Reliability, Sustainable buildings

On the development of country's rural and urban areas, the construction industry benefits immensely, which in turn benefits the economy as a whole[1–4]. Although while public infrastructure projects are essential, they frequently go over budget, which is a concern around the world. Despite this, the building industry remains one of the most prevalent in the globe. Cost overruns in building projects have a severe effect on their economic sustainability, which often results in postponement or even cancellation of the project. Possible future investments and endeavours may be threatened if the causes of project cost overruns are not addressed[5].

A delay may have been brought on by more than one entity (the client, the contractor, or structural designer), but it may also have been brought on by none of these parties such as exceptionally adverse weather conditions. This is something that neither the owner nor the contractor wants to happen, as it undermines the trust that should be present between the two parties in the event of future construction endeavors. A delay means a decrease in revenue for the owner as a result unavailable rentable space or a dependence on existing facilities. On the other hand, for the contractor, a delay means higher overhead costs as a result of a longer work period, higher material costs as a result of inflation, and increased labour cost etc. As a result, delays in construction projects give rise to discontent for all of the parties involved, and as a consequence, projects that were first thought to be profitable often turn into costly and money-losing contracts.

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Although their findings are enlightening, they neglect practical obstacles such as stakeholder collaboration, regulatory delays, and unanticipated site conditions—elements that considerably affect residential development in India. This study seeks to address this gap by assessing cost overrun drivers using a survey-based technique that includes the opinions of clients, contractors, and structural designers.

Because construction projects are comprised of a large number of interconnected aspects, including labour, cost, material, schedule, and other resources, it can be challenging to identify the specific aspects that were the primary reasons for a delay on a particular project. If the primary reasons that contribute to these delays were identified and contingency plans were made for them in a timely manner, organizations would be able to avoid or reduce the impact of these delays. In this study, these characteristics are singled out and analyzed to determine their relative significance in relation to the length of time an average project takes to complete. The purpose of this study is to determine the elements that owners, contractors and structural designer's perceive to be responsible for cost overrun in construction works and then rank those factors in order of their perceived degree of importance.

Literature review

The primary objective of the literature review is to provide a summary of the previous work that has been done on the subject of the research while also making an effort to evaluate the scope and level of the research that has been done up to this point. Cost overrun, defined as an adjustment from the anticipated cost, includes unforeseen incurred expenses[6].

According to Ogunlana et al.[7], most of delays were caused by inconsistent drawing detailing. It has been suggested by contractors that process inspection, as opposed to product inspection, would be more advantageous to the building industry. The construction industry faces yet another significant challenge in the form of its seasonal workforce. A notable weakness in the current study is the absence of region-specific studies concentrating on metropolitan centers in India, such as Chennai, where increasing urbanization and regulatory constraints substantially contribute to delays in building projects and budget overruns.

Many workers do not consider construction work to be a job that can be done all year round. These words are applicable when costs surpass the budget owing to Undervaluing the true expenses in the budgeting process[8]. According to Al-Khalil et al.[9], public utility projects are more prone to being delayed due to the fact that they are constructed in public highways, which necessitates the implementation of extra precautionary arrangements. Additionally, the completion of undertakings of this nature is highly reliant on the utilization of several pieces of apparatus, each of which frequently need for some form of maintenance or repair. Cost control seeks to oversee the development of expenses and expenditures throughout construction and offer ways to maintain construction costs within the sanctioned budget[10]. In addition to this, they need a multitude of approvals from a variety of governmental authorities, which necessitates a significant amount of preparation and coordination in order to avoid unnecessary delays. The cash flow issues and financial constraints faced by the contractor, the difficulties in securing approvals, and the necessity to select the lowest bidder without respect to pre-qualifications are some of the most significant causes that have been found. Furthermore, several previous research have been descriptive rather than analytical, lacking a systematic assessment of cost overrun drivers grounded in empirical evidence.The study by Babajide et al.[11] emphasizes the need of including financial literacy into small company operations to improve sustainability.

According to the findings of Jahren et al.[12], cost overruns on larger projects have a one to eleven percent greater likelihood of occurring than cost overruns on smaller projects. On the other hand, they brought attention to the fact that managers of major projects frequently make extra efforts to maintain low rates of cost overruns. They arrived at the conclusion that there is a higher likelihood of substantial cost overrun rates being incurred when the amount of the winning bid is lower than the engineer's estimate. They also found certain elements that contribute to cost overruns, such as the quality of the contract agreement, the type of human relations on the project, and the policies of the contractor. This study by Goodrum[13] implies that appropriate implementation and workforce adaptability are more important than just upgrading machinery and tools. Raja et al.[14] conveyed the cost overrun reduction in engineering projects can be done by adoption of affordable, sustainable, and high-performance materials assist in lower manufacturing and construction expenditures.

According to the majority of the research that has been conducted, the high cost of environmental safeguards and rehabilitation measures, the increased price of land acquisition, the modification of the project's scope, the higher costs provided by the bidders for specific work, the underestimation of the original cost, and the general increase in prices are all potential factors that could result in cost overruns.

Problem identification

Cost overruns in the construction sector provide a substantial difficulty, resulting in project delays, budget overruns, and financial losses for stakeholders. Residential construction projects in India, especially in major cities such as Chennai, frequently encounter budget overruns attributable to several issues, including insufficient planning, design alterations, material price instability, and labor inefficiencies. Notwithstanding progress in project management methodologies, cost overruns continue to be a widespread issue, undermining the economic viability of building projects. Recognizing and examining the primary factors contributing to cost overruns can assist in alleviating their effects and enhancing cost management within the construction industry.

Research gap

Prior research has found many elements that contribute to cost overruns in global building projects. Nevertheless, there is an absence of region-specific studies concentrating on residential development projects in Chennai, India. Moreover, current research frequently lacks a thorough ranking approach that combines stakeholder impressions with statistical confirmation. This study addresses this gap by utilizing a systematic data analysis methodology (Frequency Index, Severity Index, Importance Index) alongside reliability testing (Cronbach's Alpha) to deliver a more quantitative and validated evaluation of cost overrun factors in Chennai's residential construction industry.

Objectives

The qualitative investigation contributes to accomplishing the following goals:

1. To determine which issues should be prioritized as having the greatest impact on the cost overrun
2. To conduct the questionnaire and collect responses from the participants (Client, Contractor and Structural Designer)
3. To determine the Frequency Index, the Severity Index, and the Importance Index, and then rank each of these criteria accordingly.
4. To determine the reliability of the survey that was carried out by adopting Cronbach's alpha correction.
5. To propose the most effective preventative strategies for the top five causes for cost overrun.

Scope of the project

The goal of this study was to identify the reasons that are responsible for the routinely observed increases in building project costs that occur in the city of Chennai, in the Indian state of Tamil Nadu. In this regard, the inquiry has shown that there are a number of different variables, and both the significance of these variables and the impacts that they have been found to have been investigated. A survey was sent out to a variety of builders, clients and structural designers which enabled the factors to be identified. Many recommendations and preventative measures have been suggested to proactively address these cost overun issues.

Research methodology

An outline of the approach used in the initial study may be found as follows:

1. An extensive analysis of the relevant literature was conducted, and the opinions of industry people who are considered experts were also compiled. As a direct consequence of this, a number of factors that contribute to cost overruns in the context of the residential building and construction sectors were identified.
2. The completed survey questionnaire had a total of twelve components, bringing the total number of elements to eighteen when the essential particulars are taken into account.
3. The respondents were provided with a questionnaire that was divided into three parts. In the first part, also known as Part I, respondents were asked for their personal information, including the name of the responder, the name of the project, the cost of the project, the type of responder, and their level of experience. In the second part of this study, twelve causes were identified and participants were asked to rate their frequency of occurrence. Part III consists of similar questions, but the severity of the problems is addressed and an opinion is soughed out.
4. The Likert scale is analyzed statistically using the Frequency Index, Severity Index, and Importance Index. These are given a ranking and prioritized to identify the first five reasons behind the problem in these six sites.
5. A Crobach Alpha correction is carried out to measure the reliability of the work.
6. Prioritized five causes were identified based on ranking and discussed in brief to find the preventive measures.

Research approach

This research used a deductive methodology, formulating hypotheses concerning cost overrun drivers derived from existing literature and subsequently testing them using empirical data obtained from the survey. The methodology transitions from a broad theoretical framework (literature findings and research gap) to particular data-driven conclusions (rankings and suggestions derived from survey results). This systematic methodology guarantees that the results are both data-driven and statistically proven, rendering them pertinent for industry experts and policymakers seeking to reduce cost overruns in the residential building business.

Data collection

In this study, a questionnaire survey was used as a measurement tool to find and rank the causes of cost overruns. Some situations were realized to be of similar importance, and acquires professional opinions as well as other relevant data by employing a questionnaire to conduct our research. In addition to this, a literature review was conducted with the aim of providing a conceptual foundation for the study. This was done by reading a variety of different sources. The evaluation of the pertinent literature made it possible to identify potential causes that could contribute to cost overruns, as well as the effects of cost overruns and techniques for controlling and managing costs. Cost overruns in construction projects arise from several sources, some of which are controllable factors beyond control[15]. The procedure of Budget forecasts assist companies in determining whether to expand, decrease, or sustain the current state.

This was accomplished by identifying potential causes that could be found in the relevant literature. The percentage of respondents broken down by contactor, client, and structural designer is shown in Fig. 1. The assessment of previous literature was used as the foundation for the design of the questionnaire, which was subsequently circulated to experts working in the construction industry, structural designers, and clients of six sites in Chennai.

Statistical analysis

Frequency index

Rarely, Sometimes, Often, Always are the categories that are used to describe the frequency of occurrence (on 4 to 1 point scale). To order the potential reasons of delay according to the frequency with which they were

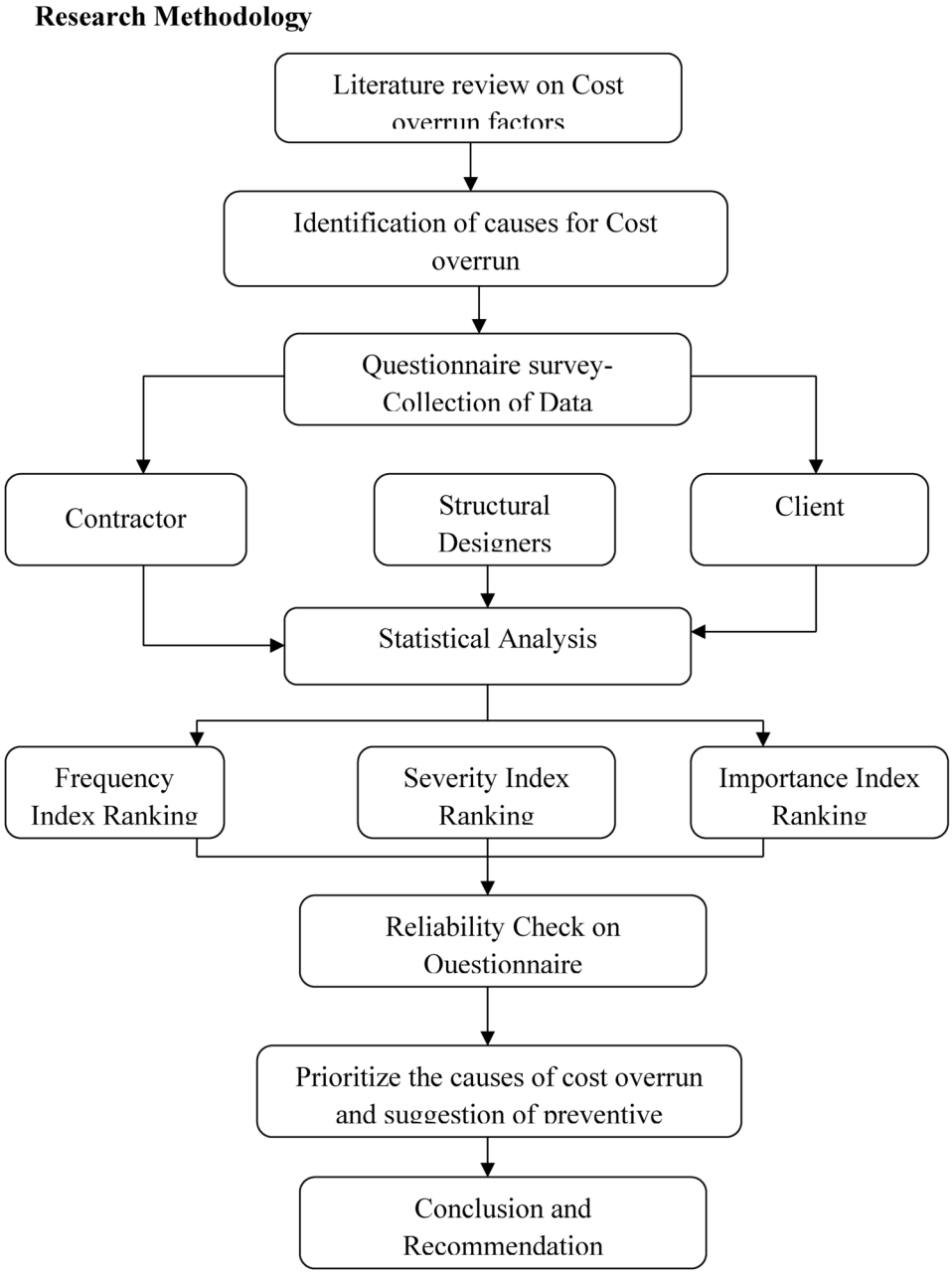

Fig. 1. Flowchart of research work.

recognized by the participants, the formula that is utilized is as follows: The Frequency Index, abbreviated as F.I., is calculated as follows:

$$F.I = \sum a\left(\frac{n}{N}\right) * 100/4$$

In this equation, 'N' represents the total number of responses, 'n' is the frequency with which each response occurred, and 'a' represents the constant reflecting the weighting that was assigned to each response. The grading runs from 1 for rarely up to 4 for always. Table 1 shows the Frequency Index and Ranking of factors that influence cost overrun.

Predominant influential factors

Overall lag in schedule of work is the primary reason of cost overruns, indicated by a high frequency index of 0.861, which stands the most influential factor. Overall lag in schedule of work is an outlier in frequency, exhibiting a much higher index than other components, signifying its considerable prevalence as a source of cost

S.No.	Category influence Cost overrun	Number of responses				Frequency Index	Ranking
		Rarely (4)	Sometimes (3)	Often (2)	Always (1)		
1	Periodic Design Changes	6	6	4	2	0.722	6
2	Non-timely payment from Client to contractor	3	8	5	2	0.667	10
3	Inadequate Skilled Labour	8	7	3	0	0.819	3
4	Inadequate supervision	7	6	4	1	0.764	5
5	Non-coordination of Contractor and Designer	4	9	3	2	0.708	8
6	Lack of Inspection by Designer	6	4	5	3	0.681	9
7	Climatic variation on execution of project	3	6	5	4	0.611	11
8	Hike in Materials Cost	2	5	6	5	0.556	12
9	Overall lag in schedule of work	10	6	2	0	0.861	1
10	Rework/ Extra work in Unforeseen situation	9	6	2	1	0.819	2
11	Inadequate design and specification	7	5	6	0	0.764	4
12	Lack of Labour Performance	6	4	7	1	0.708	7

Table 1. Frequency index and its ranking.

overruns. Rework/Extra work in unforeseen situations and Inadequate Skilled Labour exhibit high frequency indices of 0.819, signifying their substantial influence as well.

Moderate influential factors

Inadequate design and specification is ranked fourth with a frequency index of 0.764 stands the moderately dominating factor for cost overrun. Inadequate supervision and Periodic design changes are ranked 5th and 6th, respectively, with frequency indices exceeding 0.700.

Minimal influential factors

Hike in materials cost possesses the lowest frequency index of 0.556, signifying that it is not seen as a common or significant factor contributing to cost overruns. The hike in materials cost is an outlier on the bottom end, exhibiting a significantly reduced frequency index relative to the other elements, indicating it is not a predominant concern. Climatic variation in project execution and Delayed payment from client to contractor exhibit comparatively lower rankings and frequency indices, indicating they are infrequent contributors. Labor-related concerns, such as insufficient skilled labor and poor labor performance, typically emerge among the primary reasons, showing that human resource challenges are a significant source of cost overruns. Design and planning challenges such as Insufficient design and specifications, frequent design modifications significantly contribute to possible inefficiencies in the project planning phase.

Correlation matrix of frequency index for factors influencing cost overrun

Rarely	1	-0.17	-0.58	-0.82	0.95	-0.96
Sometimes	-0.17	1	-0.53	-0.12	0.12	-0.017
Often	-0.58	-0.53	1	0.39	-0.67	0.62
Always	-0.82	-0.12	0.39	1	-0.92	0.89
Frequency Index	0.95	0.12	-0.67	-0.92	1	-0.98
Ranking	-0.96	-0.017	0.62	0.89	-0.98	1
	Rarely	Sometimes	Often	Always	Frequency Index	Ranking

The positive correlation 0.95,0.12,0.39,0.62,0.39,0.89,0.12,0.62,0.89 shows most response categories "Sometimes and Rarely" indicating certain events occur more frequently, that is overall frequency index increases. According to what was anticipated, there is a negative association between ranking and the frequency index. This is because a higher frequency index correlates to a lower rank, with first place being the greatest possible rank. The "Always" response category does not have a high correlation with other categories, it may be inferred that circumstances that "always" occur are relatively independent from conditions that "rarely" or "sometimes" occur.

Severity index

Slightly, Moderate, Significant, Extreme are the categories that are used to describe the Severity of the Problem (on 4 to 1 point scale). To order the potential reasons of delay according to severity with which they were recognized by the participants, the formula that is utilized is as follows: The Severity Index, abbreviated as F.I., is calculated as follows:

$$S.I = \sum a\left(\frac{n}{N}\right) * 100/4$$

In this equation, 'N' represents the total number of responses, 'n' is the frequency with which each response occurred, and 'a' represents the constant reflecting the weighting that was assigned to each response. The grading runs from 1 for Slightly up to 4 for Extreme. Table 2 shows the Severity Index and Ranking of factors that influence cost overrun.

Predominant influential factors

Overall lag in schedule of work possesses the greatest frequency index of 0.819 and is ranked 1. This indicates that scheduling delays are regarded as a major factor contributing to cost overruns. The overall lag in schedule of work is a notable outlier, representing the most substantial element on the high end. Inadequate design and specification, Periodic design changes and Lack of inspection by designer each possess frequency indices of 0.681, categorizing them as significant drivers to cost overruns.

Moderate influential factors

The frequency index of Rework/Extra work in unforeseen situations and Non-coordination of Contractor and Designer is 0.667, signifying a modest impact. Inadequate skilled labor and lack of labor performance exhibit marginally lower frequency indices (0.653), indicating that labor-related difficulties are prevalent but not the primary worry. Inadequate supervision possesses the lowest frequency index of 0.500, indicating that, although it exerts some influence, it is regarded as one of the least significant contributors to cost overruns.

Minimal influential factors

Increase in material costs and delayed payments from client to contractor similarly exhibit poor rankings, with indices of 0.528 and 0.611, respectively. Inadequate supervision is an anomaly on the lower spectrum, with a frequency index significantly lower than other factors, indicating it is not frequently linked to cost overruns. Labor-related challenges, including skilled labor, supervision, and labor performance, contribute to the overall difficulties, albeit to a lesser extent than concerns associated with project planning and scheduling. In comparison to schedule and design difficulties, material cost increases and payment delays are less impactful in contributing to cost overruns. The factors Periodic design changes, inadequate design and specification and Lack of inspection by designer exhibit comparable frequency indices and ranks, indicating that design-related concerns are collectively influential in contributing to cost overruns. Design and planning challenges (design modifications, inspections, standards) seem to be significant contributors to cost overruns.

Correlation matrix of severity index for factors influencing cost overrun

Slight	1	0.19	-0.79	-0.7	0.95	-0.86
Moderate	0.19	1	-0.4	-0.51	0.45	-0.34
Significant	-0.79	-0.4	1	0.32	-0.73	0.61
Extensive	-0.7	-0.51	0.32	1	-0.86	0.8
Severity Index	0.95	0.45	-0.73	-0.86	1	-0.9
Ranking	-0.86	-0.34	0.61	0.8	-0.9	1
	Slight	Moderate	Significant	Extensive	Severity Index	Ranking

S.No.	Category influence Costoverrun	Number of responses				Frequency Index	Ranking
		Slight (4)	Moderate (3)	Significant (2)	Extensive (1)		
1	Periodic Design Changes	4	7	5	2	0.681	3
2	Non-timely payment from Client to contractor	3	5	7	3	0.611	10
3	Inadequate Skilled Labour	4	6	5	3	0.653	7
4	Inadequate supervision	0	5	8	5	0.500	12
5	Non-coordination of Contractor and Designer	4	6	6	2	0.667	6
6	Lack of Inspection by Designer	4	7	5	2	0.681	4
7	Climatic variation on exceution of project	3	6	5	4	0.611	9
8	Hike in Materials Cost	2	4	6	6	0.528	11
9	Overall lag in schedule of work	9	6	2	1	0.819	1
10	Rework/ Extra work in Unforeseen situation	4	5	8	1	0.667	5
11	Inadequate design and specification	6	4	5	3	0.681	2
12	Lack of Labour Performance	4	6	5	3	0.653	8

Table 2. Severity index and its ranking.

S. No.	Category influence Costoverrun	Identity of factors	FI	SI	II	Ranking based on Importance Index
1	Periodic Design Changes	F1	0.72	0.68	0.49	5
2	Non-timely payment from Client to contractor	F2	0.67	0.61	0.41	9
3	Inadequate Skilled Labour	F3	0.82	0.65	0.53	3
4	Inadequate supervision	F4	0.76	0.50	0.38	10
5	Non-coordination of Contractor and Designer	F5	0.71	0.67	0.47	6
6	Lack of Inspection by Designer	F6	0.68	0.68	0.46	7
7	Climatic variation on exceution of project	F7	0.61	0.61	0.37	11
8	Hike in Materials Cost	F8	0.56	0.53	0.29	12
9	Overall lag in schedule of work	F9	0.86	0.82	0.71	1
10	Rework/Extra work in Unforeseen situation	F10	0.82	0.67	0.55	2
11	Inadequate design and specification	F11	0.76	0.68	0.52	4
12	Lack of Labour Performance	F12	0.71	0.65	0.46	8

Table 3. Importance index and ranking.

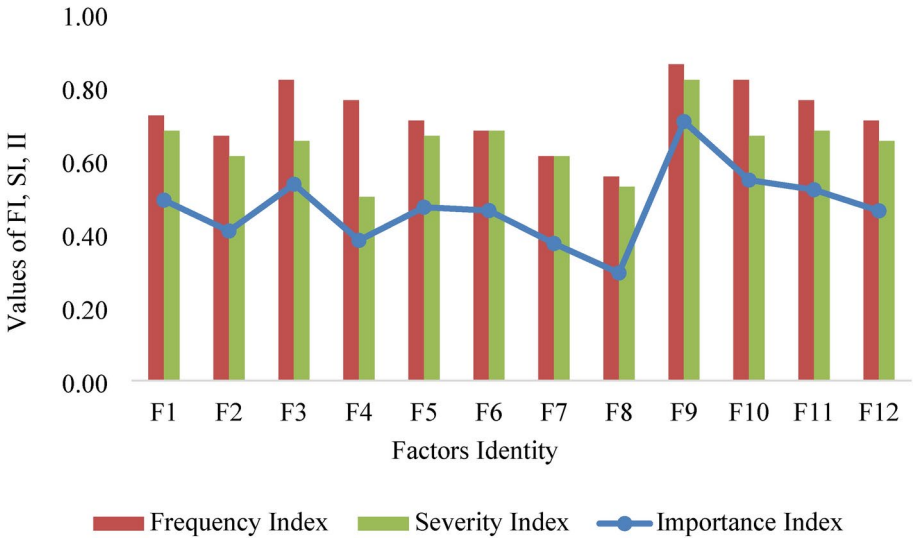

Fig. 2. Observed values in FI, SI, II.

The Severity Index exhibits a positive correlation with Slight, Moderate, and Significant replies, indicating that an increase in these responses corresponds with an increase in the severity index. The ranking has a pronounced negative association with the Severity Index, as anticipated, given that a greater frequency index correlates with a lower ranking number. The Extensive answer category exhibits a smaller link with the frequency index than the other categories, suggesting it may not significantly impact the total frequency index.

Importance index

Table 3 shows the Importance Index calculated as per the data from F.I and S.I. Figure 2 represents the graph with values of FI,SI and II based on the measurement from opinion from participants. Following is the formula that is used to determine the importance index of each factor based on the frequency index as well as the severity index:

$$I.I = F.I * S.I$$

Cost control is the identification and reduction of corporate expenditures to enhance profitability, beginning with the budgeting process (Babajide et al., 2023). According to Importance Index, the predominant influencing factor are General delay in work schedule (F9) possesses the highest Importance Index (II) of 0.71, securing the 1st position. This suggests that timetable delays are seen as the primary factor influencing cost overruns. Rework/ Extra work in unforeseen situations (F10) is ranked second with an Importance Index of 0.55, underscoring the

effect of unanticipated rework on project expenses. Inadequate Skilled Labour (F3) is ranked third with an II of 0.53, highlighting labor-related issues as a significant factor. The Indian Contract Act, 1872 Sect. 73 allows the compensation for breach of contract making delay in project. The Moderately Influential Factors are Inadequate design and specification (F11) is ranked 4th with an Influence Index (II) of 0.52. Design-related inefficiencies frequently emerge as significant factors. Periodic Design Changes (F1) and Non-coordination of Contractor and Designer (F5) are ranked 5th and 6th, respectively, with II values of 0.49 and 0.47.

The factor Hike in Materials Cost (F8) possesses the lowest Importance Index of 0.29, indicating that while rises in material costs are influential, they are regarded as the least major contributor to cost overruns. The Goods and Service Tax Act, 2017 fixed the GST rates for construction projects ranging 5% for affordable housing to 18% for commercial projects, which affects the overall cost. Climatic variation on project execution (F7) and Delayed payment from Client to contractor (F2) are ranked 11th and 9th, with II values of 0.37 and 0.41, respectively. These factors may exert a less frequent or severe influence on project expenses.

The Frequency Index (FI) and Severity Index (SI) typically exhibit a robust correlation. Common factors are often severe, as seen by the highest-ranking factors such as F9 and F10.

The Importance Index (II) seems to exhibit a pattern shaped by both frequency and severity. The overall timetable lag in work (F9) is both common and significant, resulting in its elevated Importance Index.

Inadequate supervision (F4) possesses a modest FI of 0.76 and a SI of 0.50; nevertheless, its II of 0.38 significantly diminishes its importance, resulting in a ranking of 10th. This indicates that although insufficient supervision occurs with some frequency and severity, it may not exert a direct or substantial influence on costs. Increase in Materials Cost (F8) is another anomaly. Although occurring frequently (FI of 0.56), the low severity (SI of 0.53) and relevance (II of 0.29) indicate that increases in material costs are not perceived as significantly impacting relative to other factors. Schedule delays and unforeseen rework are significant contributors to cost overruns, closely followed by labor complications and design concerns. Payment discrepancies, supervisory deficiencies, and climatic fluctuations are less significant, however they nonetheless lead to cost overruns in certain instances. Although material cost increases are evident, they are regarded as exerting a lesser influence on total project expenses relative to other considerations.

Overall lag in Schedule (F9) is the main factors with high response from the participant showing cost overrun. According to this analysis, the least importance occurs for Hike in Material cost (F8) may be due to the procurement of materials at initial stage since all six site being lie with the overall budget not exceeding 75 lakhs. Figure 3 represents the Ranking based on the Importance Index observed during the analysis.

Reliability check

In the fields of statistics and psychological tests, reliability refers to the degree to which a measure is consistent across the board. When results are consistent, a measure is reliable. It is the feature of a group of test scores that corresponds to the amount of random error from the measuring method that might be incorporated in the scores. It is a measure of how reliable the scores are as a whole. The most popular measure of internal consistency is Cronbach's alpha. It is most commonly used when a survey or questionnaire has multiple Likert items that when added together form a scale, and it is important to ascertain the reliability of the scale. Table 4 shows the Cronbach`s value observed during the Reliability Analysis.

In this analysis, lies Cronbach Alpha value for all factors that influence the cost overrun lies within the range of 0.50 to 1 which shows that all questions were set more than 50% reliable.

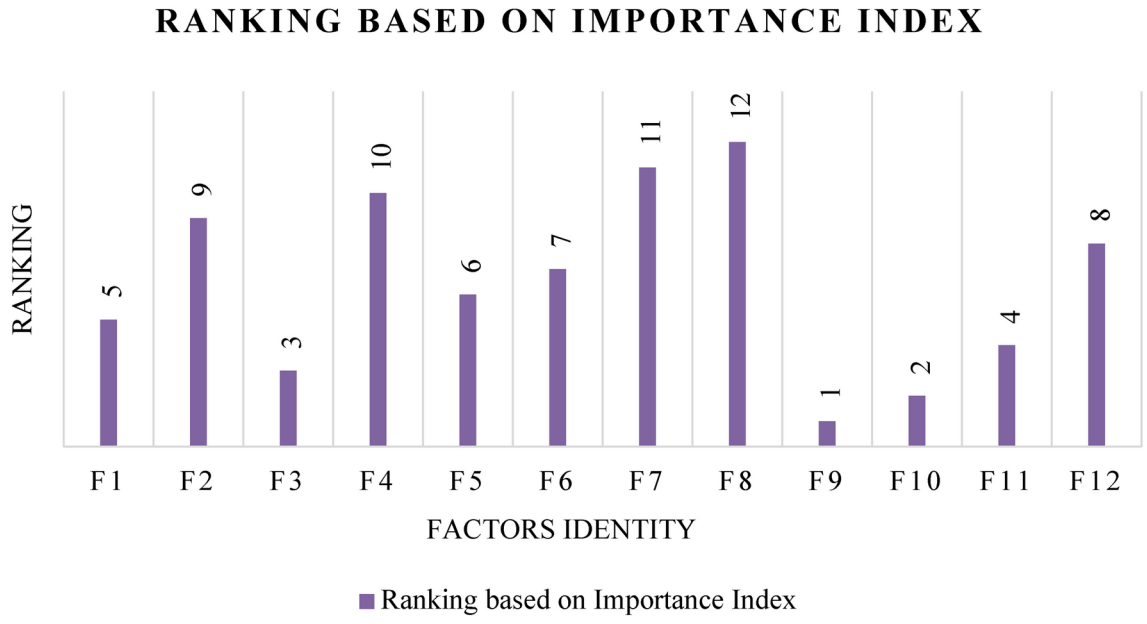

Fig. 3. Ranking of factors based on Importance Index.

S. No.	Responders	Cronbach's Alpha Value	
		FI	SI
1	Site-1 Contractor	0.7097	0.7767
2	Site-2 Contractor	0.7245	0.7766
3	Site-3 Contractor	0.7223	0.7877
4	Site-4 Contractor	0.757	0.7725
5	Site-5 Contractor	0.729	0.7624
6	Site-6 Contractor	0.7471	0.7795
7	Site-1 Structural Designer	0.7149	0.7802
8	Site-2 Structural Designer	0.7212	0.7831
9	Site-3 Structural Designer	0.7057	0.7637
10	Site-4 Structural Designer	0.7408	0.7517
11	Site-5 Structural Designer	0.7227	0.7573
12	Site-6 Structural Designer	0.755	0.7834
13	Site-1 Client	0.7535	0.7828
14	Site-2 Client	0.7488	0.7618
15	Site-3 Client	0.7388	0.7477
16	Site-4 Client	0.7386	0.7914
17	Site-5 Client	0.6924	0.7733
18	Site-6 Client	0.7287	0.7779

Table 4. Cronbach alpha value for responses.

Important factors influence cost overrun

(i) Overall lag in Schedule

The Importance Index for Overall lag in Schedule of project is 0.71 and it ranges the top position in this study. The expected amount of time that elapses before or after each activity is a significant issue that has a tendency to receive insufficient consideration but has the potential to adversely affect the total duration of the project. RERA Real Estate (Regulation and Development) Act, 2016 mandates strict timelines on project completion with Sect. 42 (l) (D). Many criteria were taken into consideration: the weather, the location, the traffic, the equipment, and the type of soil. One of the most crucial factors that might have a major impact on the functioning of the construction sector is the weather. Many studies have concentrated on the question of how various aspects of the weather, such as temperature, precipitation, wind speed, and others, influence the rates of output at building sites. Contractors also perceive the availability of manpower and equipment to be key contributors to project delays.

(ii) It was decided by contractor and client that an error that occurred when the building was being constructed was the second most critical issue overall, and it was classified in the category of variables relating to the contractor. The Importance index was calculated to be 0.71. The overwhelming majority of people who responded to the survey thought that an increase in prices would be unavoidable in the event that the contractor was found to be accountable for any problems that occurred while the building was being constructed. If a contractor does not have enough experience with the project's type and location, it could cause a delay in the project's execution, which would add to the cost of the project. An increase in price may result from both of these elements. This aspect is primarily related with the lack of experience that the contractor possesses. It is possible that the work will need to be disassembled and redone if the contractor does not complete the job in accordance with the conditions of the contract or installs materials that have not been allowed. Alternatively, the job may need to be redone entirely. The completion of this rework would invariably slow down development and, as a consequence, it lead to an increase in costs. Notwithstanding this, participants in the survey conducted agreed that errors made during construction contributed to an increase in cost.

Mitigating strategies

Cost overruns in residential construction projects occur due to several circumstances, including delays, rework, labor shortages, and design inefficiencies. To resolve these difficulties, several mitigation measures may be employed to enhance project efficiency and control of funds.

The primary factor contributing to cost overruns is the overall delay in project timelines, as shown by the highest Importance Index (II = 0.71). To address this, sophisticated project management methodologies like MS Project, and Building Information Modeling (BIM) may be utilized to enhance scheduling and resource

distribution. Consistent coordination meetings among contractors, designers, and clients may enhance alignment and facilitate proactive problem-solving, hence minimizing the likelihood of project delays.

Rework and additional labor resulting from unanticipated circumstances can substantially contribute to cost overruns (II = 0.55). This may be mitigated by comprehensive pre-construction planning and risk assessments that facilitate the identification of potential mistakes prior to execution. Implementing ISO 9001-certified quality control techniques at each level guarantees compliance with requirements, minimizing expensive corrections. Automated approval systems and digital documentation tools help speed the process and avoid superfluous alterations during construction. Personnel inefficiencies, especially insufficient skilled workers (II = 0.53), represent a significant issue. To resolve this, worker training initiatives in partnership with the National Skill Development Corporation (NSDC) can be implemented to improve labor competency. Moreover, transitioning to prefabrication and modular building techniques can diminish dependence on on-site skilled personnel while preserving construction quality. The implementation of automation and AI-driven building methods, like robotic bricklaying and 3D printing, can improve efficiency and alleviate labor shortages.

Design-related inefficiencies, including insufficient specifications and frequent design alterations, significantly contribute to increased project costs (II = 0.52). To address this, early-stage communication among stakeholders is crucial, guaranteeing alignment among architects, engineers, and clients prior to the commencement of construction. By using these mitigation techniques, construction stakeholders may proficiently control cost overruns, augment project efficiency, and boost financial predictability.

Research contribution

Although previous studies have offered a comprehensive insight into cost overruns, they have not adequately tackled the Variations by region and project type, particularly with residential structures in Indian urban areas. In this study, Quantitative assessment of cost overrun determinants with structured indices. Analysis based on stakeholders that include viewpoints from clients, contractors, and designers and Evaluation of reliability to confirm the consistency of results is developed. This study addresses these deficiencies by providing a realistic and statistically substantiated method for identifying and controlling cost overruns in residential building projects in Chennai.

Conclusion

Cost overruns seem to be a persistent problem in the construction sector, profoundly affecting project feasibility, profitability, and stakeholder comfort. This study systematically examined the primary factors leading to cost overruns in residential building projects in Chennai using a structured methodology utilizing Frequency Index, Severity Index, and Importance Index. The findings indicate that delays in scheduling, rework due to unanticipated circumstances, insufficient skilled personnel, and design and specification deficiencies are the primary factors contributing to cost overruns.

This strength of this research is its quantitative, data-driven methodology, which identifies and classifies cost overrun drivers based on actual evidence. The accuracy of the gathered data was confirmed by Cronbach's Alpha, assuring the consistency of results. The statistical analysis of survey responses indicated the primary variables impacting cost overruns as Overall lag in schedule (FI = 0.861, SI = 0.819, II = 0.71), which is the highest-ranked factor suggesting frequent project delays. Conversely, increases in material costs (FI = 0.556, II = 0.29) and climatic fluctuations (FI = 0.611, II = 0.37) were identified as fewer important factors contributing to cost overruns in Chennai, likely due to early procurement and stable weather patterns. The reliability of the questionnaire is checked using Cronbach`s alpha value, which ranges higher than 0.50 for all criteria. The study addresses a significant research void by concentrating on residential developments within an Indian metropolitan context, a domain that has been inadequately explored in previous research.

This findings can assist clients, contractors, and project managers in proactively mitigating cost overrun risks via enhanced planning, resource management, and stakeholder coordination. Subsequent study may expand on these findings by investigating technology interventions, regulatory modifications, and real-time cost monitoring measures to further improve cost management in building projects. Implementing the recommendations outlined in this report would enhance project efficiency, cost predictability, and overall economic sustainability within the construction sector.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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References

1. Kadupu, R. et al. Assessing the thermal insulation properties of thermoplastic bricks for energy-efficient building solutions. *Matéria (Rio de Janeiro)* https://doi.org/10.1590/1517-7076-rmat-2024-0583 (2024).
2. Exploring the role of ecosystem based–adaptation in climate change mitigation and resilience building. (2024). Global NEST Journal. https://doi.org/10.30955/gnj.05930
3. Environmental Impact and Carbon Footprint Assessment of Sustainable Buildings: An Experimental Investigation (Adsorption Science & Technology (2022) 2022 (8130180) https://doi.org/10.1155/2022/8130180)
4. Ali, S., Hayat, K., Hussain, I., Khan, A. & Kim, D. Optimization of distributed energy resources operation in green buildings environment. *Sensors (Basel, Switzerland)* **24**(14), 4742. https://doi.org/10.3390/s24144742 (2024).
5. Olaniran, O. J., Love, P. E. D., Edwards, D. J., Olatunji, O. A. & Matthews, J. Cost overruns in hydrocarbon megaprojects: A critical review and implications for research. *Project Manage. J.* **46**(6), 88–101. https://doi.org/10.1002/pmj.21556 (2015).

6. Amini, S., Rezvani, A., Tabassi, M. & Malek, S. S. Causes of cost overruns in building construction projects in Asian countries; Iran as a case study. *Eng. Constr. Archit. Manag.* **30**(7), 2739–2766 (2023).
7. Ogunlana, S. O., Promkuntong, K. & Jearkjirm, V. Construction delays in a fast-growing economy: Comparing Thailand with other economies. *Int. J. Proj. Manag.* **14**(1), 37–45 (1996).
8. Ankrah, N. A. & Manu, E. (2023). Project cost management. In *Building a body of knowledge in project management in developing countries*, 215–260
9. Al-Khalil, M. I. & Al-Ghafly, M. A. Important causes of delay in public utility projects in Saudi Arabia. *Constr. Manag. Econom.* **17**(5), 647–655 (1999).
10. Kermanshachi, S. & Pamidimukkala, A. Robustness analysis of total project cost and schedule delay and overrun indicators of heavy industrial projects. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **15**(2), 452–459 (2023).
11. Babajide, A. et al. Financial literacy, financial capabilities, and sustainable business model practice among small business owners in Nigeria. *J. Sustain. Financ. Invest.* **13**(4), 1670–1692 (2023).
12. Jahren, C. & Ashe, A. Predictors of cost overrun rates. *J. Constr. Eng. Manag.* **116**(3), 548–551 (1990).
13. Goodrum, P. M. & Haas, C. T. Partial factor productivity and equipment technology change at activity level in US construction industry. *J. Constr. Eng. Manage.* **128**(6), 463–472 (2022).
14. Raja, T. et al. Sustainable innovations: Mechanical and thermal stability in palm fiber-reinforced boron carbide epoxy composites. *Results Eng.* **24**, 103214. https://doi.org/10.1016/j.rineng.2024.103214 (2024).
15. Alshihri, S., Al-Gahtani, K. & Almohsen, A. Risk factors that lead to time and cost overruns of building projects in Saudi Arabia. *Buildings* **12**(7), 902 (2022).

Author contributions

Conceptualization and Study Design: Dr. M. K. Soundarya developed the study concept and designed the research approach. Data Collection: A. Logeshkumaran, Elumalai PV, Liu Yu conducted the data gathering, managed participant recruitment, and ensured ethical standards. Data Analysis: P. R. Kalyana Chakravarthy, Elumalai PV, S.Baskar performed data analysis, interpreted results, and verified data accuracy. Writing – Original Draft: Dr. M. K. Soundarya, S. Baskar drafted the manuscript, including literature review, methodology, and discussion. Writing – Review and Editing: P. R. Kalyana Chakravarthy, J. Anil reddy reviewed and edited the manuscript for critical intellectual content, clarity, and coherence. Funding Acquisition: S. Prabhakar, S. Baskar secured funding and resources necessary for the study. Supervision: Dr. M. K. Soundarya, P. R. Kalyana Chakravarthy, supervised the project and provided guidance throughout the research. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, ensuring accuracy and integrity in the research process.

Competing interests

The authors declare no competing interests.

Consent to participate declaration

All participants in this study were provided with a full explanation of the purpose, procedures, potential risks, and benefits of the research. Written informed consent was obtained from each and every participant prior to their involvement in the study. This study adheres to ethical guidelines.

Ethical declaration

This study follows ethical norms to preserve participant's rights. Before data collection, participants give informed consent to use and preserve their data. All personal information is kept secret, maintained securely, and anonymized wherever feasible to safeguard participant's identity. Participants confirm that they understand and agree to these conditions and that this research meets ethical standards by participating. Ethical Standard followed throughout the study involves "General Data Protection Regulations (GDPR)" in which Consent to data collection and usage of data, data security, right to access and correction of data and transparency of data were done.

Additional information

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