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ARTICLE

A Study on Factors Influencing Cost Overrun in High-rise Building Construction across India

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ABSTRACT

Cost overrun is a common problem in construction projects worldwide. Most Indian construction projects, particularly those involving high-rise buildings, have had severe cost overruns. For managers, architects, engineers, and contractors, completing building projects within the specified cost budget has become the most important and hard assignment. Since it is common for high-rise building projects to go over budget, the aim of this study is to find out the causes of cost overruns and provide effective measures. The study found 70 cost overrun factors based on a comprehensive literature review and expert opinions. A Google form questionnaire was distributed to 150 construction professionals across India. After following up, 101 of the 150 responses were received. A five-point Likert scale was used and the acquired data was analyzed and ranked using the Relative Importance Index (RII) technique. According to the findings of RII, the top ten critical factors influencing cost overruns were frequent change orders during construction by the owner, delay in construction, escalation of material prices, market inflation or deflation, rework, frequent changes in design, inaccurate evaluation of the project timeline, unforeseen ground condition, inaccurate quantity take-off, and delay in progressive payment by the owner. Spearman's rank correlation test revealed that there is a very significant relationship between the rankings of factors provided by the owner, the consultant, and the contractor. In addition, a factor analysis tool in the SPSS software was also used to categorize the seventy factors into sixteen core components. The top ten critical factors were presented to subject matter experts, and their suggestions were being compiled. These results are expected to help construction professionals minimize cost overruns, improve cost control measures, and initiate future research.

Keywords: Cost overrun; High-rise buildings; RII; Factor analysis; Subject matter expert (SME); India

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1. Introduction

Metrics, such as cost and time, are common measures of construction project performance against its baseline [1]. Delays on projects are also accompanied with costs that are unbudgeted [2]. Cost performance can be considered the leading metric in construction worldwide out of the four main constraints of quality, scope, time and cost [3]. In a study into construction projects in Asian countries, Huda Mahmood (2021) found only about 13% of construction projects were completed within the specified budget, and the real cost of the project was 28 percent more than the expected cost [4]. This view is consistent in both developed and developing nations and even small island developing states [5]. Developing an accurate estimate, given all the recent advancements in technology and intelligence, and executing a project within the estimates are a few of the most significant challenges that the construction sector face in reality. Out-of-control costs places pressure on investments, which leads to consequential sub optimal investment decision-making, which can further drive up costs. This leads to the waste of national resources and potentially unethical practices and illegal activities. As a consequence of this, it is very necessary to determine the factors that lead to cost overruns in order to avoid and reduce issues [6].

Within the Indian context, of 555 projects worth Rs 150 Crore, a minimum of 179 projects had documented cost overruns approximating 1.23 Lakh Crore [7]. Thus, in examining the performance of the project and comprehending the financial risks associated with the project's execution, it is essential to address the issue of cost variance. The organization's profits suffer from the cost discrepancies that result from a project going over budget. This leads to funds being drawn from other planned projects to absorb the cost overruns on ongoing projects. Overall, projects are left incomplete and economic activities are adversely affected. Despite common familiarity with cost overruns, the reasons for their recurrence have not been fully explored. This gap leaves room to contribute to the body of knowledge on the cost overrun phenomenon.

In accordance with the International Building Code (IBC) 2000, buildings with a height of 75 feet or more, as measured from the level at which fire department vehicles can gain access to the building to the floor of the highest occupiable story, are considered high-rise structures [8]. Considered a specialist type of construction project, high-rise structures are typically accompanied by intricate designs and integration services. This increases the project's susceptibility to coordination and communication issues resulting from the inherent increase in complexities in construction. In 2019, the demand for high-rise structures has increased to previously unseen levels as Indian cities are under increasing pressure to develop vertically. For example, more than 52% of the 1,816 housing projects that were launched during 2019 in the top 7 cities were high-rises structures with a ground plus 20-floor structure [9].

To achieve an improved economic success rate on projects, an understanding of the variables or factors limiting economic sustainability and ultimately contributing to cost overruns is warranted. In other words, construction projects are successful if the key factors that cause cost overruns are identified and evaluated in advance, and strategies are developed in praxis for construction professionals to control unaccounted costs. The factor school of thought, based primarily on contingency theory, dominates cost overrun research [5]. This is primarily due to the context-specificity nature of cost overruns varying geographic, economic and project conditions. The research is proposed to highlight the most common factors in current high-rise building projects across India. Therefore, construction professionals will be able to use it to avoid future cost overruns and improve cost control measures.

The construction industry in India is a leading indicator of economic health since it promotes the creation of new businesses across a wide range of sectors. In the fourth quarter of 2020, the construction sector in India was estimated to be worth over 2.7 trillion Indian rupees [10].

The study was focused on identifying the critical factors that cause cost overruns in high-rise building

projects. The researcher considered construction firms across India for a questionnaire survey, with a focus on a few smart cities. Based on the cost overrun issues surrounding high-rise structures in India, the main objectives of this study include the following:

1) To identify and rank the most critical factors of cost overrun in high-rise building constructions by relative importance index (RII) method.

2) To check the degree of relationship between the rankings of factors provided by the owner, the consultant, and the contractor, using Spearman's rank correlation test in SPSS software.

3) To uncover the core components of cost overrun factors and their relationships using factor analysis in SPSS software.

4) To collect suggestions from SMEs (subject matter experts) for minimizing or avoiding cost overruns associated with high-rise building construction projects.

2. Literature review

The term "cost overrun" refers to any changes in costs, such as growth, an increase escalation, variance, deviation, or discrepancy between the initial and final contract amount [11]. "Cost" is one of the most significant and widely influencing aspects in the project management life cycle; it may be seen as a driver of project success [12]. Cost overruns in the construction phase of a project may be ascribed to a variety of factors. Each phase of a project's life cycle is responsible for the creation of these factors. These phases are the stage for planning the project, the stage for procurement, and the stage for construction [11].

The discrepancy between the actual capital costs of an investment and its estimated costs is referred to as a cost overrun. The difference may be expressed either in absolute or relative terms, depending on the context. When evaluated in absolute terms, cost overrun is determined by subtracting actual costs from estimated costs [13].

Cost overruns, also known as the difference between final and winning costs, are something that may occur at any point of a project, from the planning stages all the way through to the completion [14].

The term "cost under-run" is used to describe the scenario in which the value of cost overrun is negative. Hyosoo Moon (2020) in research classified the levels of cost overrun into three categories that are under-run, medium overruns, and high overruns. Projects are considered to be near/under-run if they are finished with a cost increase of less than 5 percent. The cost of completing a project is considered to be medium if it increases by between 5 and 20 percent over its original estimate. Projects that are considered to have high overruns are those that finish with a cost increase that is greater than 20 percent [11].

Cost overrun in big capital investment projects may be very detrimental, resulting in significant financial losses for investors and taxpayers, putting the senior executives of such organizations at risk, and even causing the companies to go bankrupt [13]. In the construction industry, cost overruns are a common occurrence. Overstretched budgets are a major problem in the construction industry, which has a direct impact on the country's GDP [15]. This can result in dispute and litigation, or, in the worst-case scenario, projects may be abandoned entirely [16].

Adnan Enshassi (2009) identified the factors influencing the success of regional construction projects in Palestine and results revealed that *inaccurate quality take-off, design changes, resources constraint, unsettlement of the local currency in relation to dollar value, lack of cost planning/monitoring during pre-and post contract stages, delay in construction, improvements to standard drawing during construction stages, supply of raw materials and equipment by contractors, fluctuations in the cost of building materials, project materials monopoly by some suppliers, increment of materials prices due to continuous border closures, funds and associated auxiliaries not ready* were the most significant factors affecting project performance [17].

Ahmed Mohammed Kamaruddeen (2020) said that the cost overrun between 5 and 10 percent of the original estimate is a common problem for Malaysian construction projects. Following an analysis of the collected data using The Relative Importance

Index (RII), the most critical cost overruns factors in Malaysian construction are *shortage of material, lack of plant and spare parts of equipment, acceleration required by clients, change of work scope or changes in material specification by clients, mistakes during construction, fluctuation in prices of raw materials, shortage of workforce, lack of skilled labour, poor project management, poor cost control and awarding of a contract to the lowest bidders* [18].

Kavuma, Andrew (2019) conducted a study on the uneven shapes of the façade of freeform buildings. He believed that time and money are often wasted on freeform initiatives [19].

Oladapo, A. A. (2007) conducted a study on the effects of change orders in South Africa, which are common in construction projects and have been investigated by a number of authors. The goal of this research was to quantify the impact that changes have on project duration and cost. Fifty people involved in the project were surveyed through a questionnaire to determine the factors leading up to and after the project's deviations. Thirty completed construction projects had their costs and durations recorded. In the study, F-tests and t-tests, as well as significance indexes, were utilized. Cost and time overruns were shown to have been significantly influenced by *change order*, with the former accounting for around 79% and the latter for 68% of the projects examined, respectively. Variations were shown to have a similar impact on project costs and delays regardless of project size or type [20].

Chan, Caroline TW. (2012) analyzed a total of 79 valid replies from Hong Kong construction firms, using exploratory factor analysis. Eight components were retrieved from the data, and their latent qualities were determined by referring back to the expert opinions gathered from the telephone interviews. This research also identified 8 critical factors influencing cost overruns in Hong Kong project such as *project duration, project complexity, site layout, regional economic condition, procurement arrangement, stakeholders' interest financial and insurance charges, and contractor's design requirement* [21].

Hemanta Doloi (2013) conducted an extensive literature analysis and took feedback from important industry stakeholders to identify factors related to cost performance. *Planning and scheduling deficiencies, Methods of construction, effective monitoring and feedback process, Complexity of design and construction and improper control over site resource allocations issues* have the greatest influence on cost performance from the viewpoints of customers, consultants, and contractors [3].

Kai Chen Goh (2015) said that cost overruns are a prevalent concern in the Malaysian construction sector and that they may have an impact on the overall performance of a construction project. The Relative Importance Index (RII) method was used to examine the data from the respondents. The results identified that *Fluctuations in raw material prices, design issues, poor project (site) management, and lowest bidding procurement method* are the main causes of cost overruns in construction [22].

K.C. Iyer (2005) provides the results of a survey questionnaire focused on the factors influencing the cost performance of Indian construction projects. After collecting data from 55 success and failure qualities via literature reading and in-depth interviews, seven variables were derived by factor analysis. *Short bid preparation time, hostile socio-economic and climatic conditions, conflict among project participants, presence of poor project specific attributes and non-existence of cooperation, aggressive competition at the tender stage, ignorance and lack of knowledge, and reluctance in timely decision* were all factors that negatively impact the cost performance of projects [23].

Long Le-Hoai (2008) said that construction projects in Vietnam often go over budget and behind schedule. He interviewed 87 Vietnamese construction industry professionals and used a questionnaire survey to learn more about the root causes of this problem. The result showed that the five major factors affecting cost overruns in Vietnam are *poor site management and supervision, design changes, poor project management assistance, financial difficulties of the owner, and financial difficulties of contractors*. He also conducted Spearman's rank correlation tests

to check the difference between the project partners' points of view and none of the project partners' points of view was found different [24].

Muhammad Ali Musarat (2021) stated in his research that the costs of construction materials, labour pay, and equipment hire rates all fluctuate on a yearly basis, it may be argued that the economics and budgeting of the majority of construction projects do not take *inflation* into consideration, resulting in cost overruns [25].

N.R. Mansfield (1994) analyzed the information about past construction projects to discover what factors contribute to schedule delays and cost overruns. The questionnaire survey was conducted with around fifty Nigerian construction industry professionals from various client, consultant, and contractor organizations. According to the findings, *Materials shortages, overall price fluctuations, inaccurate estimating, and poor contract management, attributed to finance and payment arrangements* are all held responsible for the cost overruns [26].

Remon Fayek Aziz (2013) stated that cost overrun is a highly regular problem in almost all wastewater projects and construction sites. The questionnaire survey was carried out with experts and representatives from commercial, governmental, and regional general construction companies. According to the results, the major contributors to cost overrun are *wrong method of cost estimation, additional work, lowest bidding procurement method and bureaucracy in bidding/ tendering method, inflation, unexpected ground conditions, mode of financing and payment for completed work, inaccurate cost estimation, and fluctuation in prices of raw materials* [27].

Richard Ohene Asiedu (2020) collected information from 131 respondents, mostly from the construction sector of Ghana's governmental procurement institutions. Using factor analysis, they were able to break these detailed causes of construction cost overruns into their core components. According to the findings, there are often four primary reasons why public construction projects end up costing more than originally anticipated. *A lack of effective coordination among contracting parties, change orders, a project's weak institutional and economic environment, and poor contract planning and supervision* are the four most common reasons for cost overruns [28].

Richard Ohene Asiedu (2017) conducted his studies on Predicting whether or not a project will go over budget before the contract is signed is vital for creating the necessary preventative measures. Using a survey methodology, data on 321 finished academic projects are collated. The model is built using multiple linear regression analysis. Overruns were seen to be affected by five distinct factors: *The financial categorization of the contractor, the number of stories, the total floor space, the source of funding, and the original contract amount* [29].

Samuel Famiyeh (2017) did a survey with consultants and contractors who worked on about 60 government school building projects. The factors contributing to construction delays and cost increases were ranked in order of priority, and their relative relevance was then calculated. The findings revealed that major factors of cost overruns are *Material price fluctuations, lack of communications plans, financial difficulty by client, poor feasibility and project analysis, delays in payments of completed works, variations in designs, and poor financial management on site* [30].

Savita Sharma (2019) conducted extensive literature review and took expert opinions to determine 55 significant risk factors contributing to cost overruns in Indian construction projects. A new index, the fuzzy index for cost overrun, was computed to show the severity of a given factor's chance of causing a cost overrun. These risk magnitudes were used to assign relative significance to the multiple factors. *Financial difficulties of contractors, additional work, frequent design changes, inflation, fluctuating material prices, inaccurate time and cost estimates, lowest bid procurement policy, unrealistic contract duration, mistakes and discrepancies in the contract document, and inappropriate government policy* were all recognized as top ten causes of cost overruns in the Indian construction industry [31].

Serdar Durdyev (2021) said that since 1985,

construction management journals have regularly reported on the topic of project cost overruns and this research was proposed to look into their root reasons. It was focused on resource-related, economic/financial, and political issues; however, the problem was mostly seen in developing nations by the researcher. They presented and spoke about the top 10 reasons for cost overrun. *Inaccurate estimation, poor communication, price fluctuations, poor planning, ground/soil conditions, experience and competence, contract management issues, weather, design problems and incomplete design, financial problems/poor financial management, and stakeholder's skill* were all main reasons for cost overrun [32].

Serdar Durdyev (2017) proposed a study to address a large gap in the literature by identifying the main causes of residential construction cost overruns in Cambodia, taking into account the unique operational background of the country's residential construction industry. Exploratory factor analysis was used to examine responses from a survey sent out to contractors and project managers in the industry. From a total of 26 factors, the researchers were able to identify the following three as the most significant causes of cost overruns: *ineffective project and cost management; inadequate project financing; and unanticipated risks*. These accounted for 53, 22, and 16% of the variation that constituted low-cost performance output in the sector [33].

Sowmya Narayanan (2019) used quarterly information from the Ministry of Statistics and Program Implementation's website portal, and examined the time and cost overruns of 30 big infrastructure projects in India. *Poor performance of contractor, general price escalation, law and order problems, delay in the supply of equipment, high capital cost and delay in land acquisition* were cited as the most critical reasons for time and cost overruns [34].

Soo-Yong Kim (2018) identified the contributors to cost overruns in recent Vietnamese hospital construction projects. Two common techniques, questionnaire surveys and exploratory factor analysis were used for data analysis. *Additional labour, material costs and delays* were identified as the primary contributors to hospital project budget overruns [35].

Swapnil P. Wanjari (2016) conducted a brief survey with 190 construction industry experts in India and identified the 15 most frequent causes of cost overruns. He got a total of 85 replies, which we evaluated using SPSS's array of statistical packages, including the analysis of variance (ANOVA) and the factor analysis tool. This research revealed the top three causes influencing cost overruns, including *the increase of raw material prices, delays in scheduled activities, and a lack of coordination between construction partners* [36].

Yaw Frimpong (2003) stated that groundwater construction projects in Ghana are not immune to the common problems of construction, such as delays and cost overruns. The research found that *escalating material prices, material procurement, poor contractor management, inadequate technical performance, and monthly payment difficulties from agencies* were the primary reasons for delay and expense overruns in groundwater project development [37].

3. Research methodology

Project cost overruns have been widely investigated by reviewing literature, including journal articles, websites, and other sources. These reviews and expert opinions resulted in the identification of 70 cost overrun factors. A Google Form with a questionnaire was created, and approval was taken from the project guide and an industry expert. This Google form was sent to 150 construction professionals across India, and 101 individuals responded. The RII method was used to rank the collected data. Spearman's Rank Correlation test was employed in SPSS to check the degree of relationship between the rankings of factors provided by different groups of respondents. Factor analysis was also used in SPSS to uncover the core components of cost overrun factors and their relationships. After data analysis, the top ten critical factors were determined and presented to SMEs (subject matter experts) for advice on how to avoid the critical factors. Based on the findings, a conclusion was drawn. **Figure 1** illustrates more details.

Research Strategy: Quantitative research and qualitative research are the two primary methods of research that may be conducted. In this study, a quantitative approach was used, and as a result, a research questionnaire was developed in order to identify the factors that contribute to budget overruns during the construction of high-rise buildings in India.

Research Design: An organization's goal or scientific inquiry, as well as its means of data collecting and analysis, are all examples of research designs [38]. As can be shown in **Figure 1**, this methodology will provide a summary of the paper's design, including the introduction, research goals and purpose, research literature, data collecting, and analysis.

Research Sample: Research samples come from construction industry clients, contractors, and consultants who have direct experience with building construction. Project owners may be either public or private organizations, while other consultants are from private organizations.

Key factors of cost overruns for questionnaire survey

After identifying the general cost overrun factors from the literature review, the opinions of industry professionals were also collected in order to compile a shortlist of the primary factors that contribute to cost overruns in the construction of high-rise building projects, which are illustrated in **Table 1**.

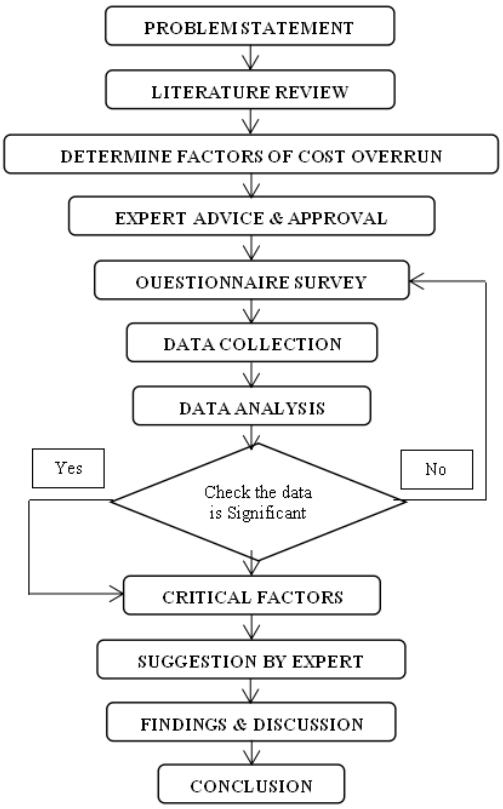

Figure 1. Research methodology flow chart.

Table 1. List of factors finalized for questionnaire survey.

Code No.	Factors causing cost overrun	Category
Estimation and Finance-related factors causing cost overrun		
EF-F1	Poor pre-construction budget	Estimation
EF-F2	Inaccurate quantity take-off	
EF-F3	Wrong unit cost of materials	
EF-F4	Wrong estimation method	
EF-F5	Difficulties in project financing by owner	Finance
EF-F6	Delay in progressive payment by owner	
EF-F7	Incorrect financial & payment methods from owner site	
EF-F8	Poor financial control on site by contractor	
Design and Contract-related factors causing cost overrun		
DC-F1	Mistakes and errors in design	Design
DC-F2	Frequent changes in design	
DC-F3	Delay in approving drawings	
DC-F4	Delay in inspection and approval of completed works	
DC-F5	Incomplete design at the time of tender	

Table 1 continued

Code No.	Factors causing cost overrun	Category
DC-F6	Poor Contract management	Contract
DC-F7	Lowest bid win	
DC-F8	Contractual claims, such as, extension of time with cost claims by contractor	
DC-F9	Mistakes & discrepancies in contract document	
Management-related factors causing cost overrun		
M-F1	Not conducting feasibility study of the project	Management
M-F2	Poor site management & supervision by contractor	
M-F3	Poor project management by PMC (project management consultant)	
M-F4	Inaccurate evaluation of projects timeline	
M-F5	Inadequate planning and scheduling	
M-F6	Inadequate monitoring the work progress by contractor	
M-F7	Lack of cost reports during construction stage	
M-F8	Lack of communication & coordination between construction parties	
M-F9	Conflict between project parties	
M-F10	Delays in issuing information to the contractor during construction stage	
Construction-related factors causing cost overrun		
C-F1	Delay in construction	Construction
C-F2	Rework	
C-F3	Non-performance of subcontractors and selected suppliers	
C-F4	Failure to apply safety rules and regulation within the contractor's organization	
C-F5	Project size	
C-F6	Complexity of project	
C-F7	Mistakes during construction by contractors	
C-F8	Frequent change orders during construction by owner	
C-F9	Owner interference	
C-F10	Work suspension by owner	
C-F11	High quality of work required by owner	
C-F12	Risk & uncertainty related with projects	
C-F13	Poor experience of the contractor	
Material and Equipment-related factors causing cost overrun		
ME-F1	Shortage of materials in the market	Material
ME-F2	Escalation of material price	
ME-F3	Delay in material delivery	
ME-F4	Poor material handling on site	
ME-F5	Changes in material specification and type	Material
ME-F6	Low quality of materials	
ME-F7	Delay in material procurement	
ME-F8	Frequent breakdown of construction plants and equipment	Equipment
ME-F9	High transportation cost	
ME-F10	High cost of machinery	
ME-F11	Equipment operators skill level is low	
ME-F12	High maintenance cost of machinery	

Table 1 continued

Code No.	Factors causing cost overrun	Category
Labour-related factors causing cost overrun		
L-F1	Lack of safety measures taken by labour	Labour
L-F2	Strike	
L-F3	Difficulties in monthly payments from agencies	
L-F4	High cost of labour	
L-F5	Poor Labour productivity	
L-F6	Lack of adequate manpower	
L-F7	Inadequate & insufficient skill of labour	
L-F8	Lack of labour training	
L-F9	Labour absenteeism	
L-F10	Excessive over time	
External factors causing cost overrun		
E-F1	Market inflation/ deflation	External
E-F2	Unforeseen ground condition	
E-F3	Unpredictable weather conditions	
E-F4	Insurance & accidents	
E-F5	Corruption	
E-F6	Security problems	
E-F7	Problems with neighbours	
E-F8	Difficulties in importing equipment and materials	

Questionnaire design

The questionnaires were developed in such a way that they take into consideration all seventy factors that were nominated as potential causes of cost overruns, as indicated in **Table 1**. Additionally, the questionnaires were prepared with the purpose of answering the research questions. A few roundtable talks and feedback sessions were held with experts working in the industry in order to verify the listed factors in relation to the Indian construction industry.

Contents of the questionnaire

The questionnaire had three sections comprising general information, questionnaires and suggestions from respondents about the causes of cost overrun. To get opinions on the factors that affect cost overruns, a five-point Likert scale with options (1. Strongly agree, 2. Agree, 3. Neither agree nor disagree, 4. Disagree, 5. Strongly disagree) were specified, where respondents were asked to mark their level of agreement to every question.

Questionnaire distribution

The questionnaire survey was constructed using an internet-based web platform known as "Google Form" and it was sent to respondents using the same piece of software. They are able to make use of the questionnaire since it is readily available to them on a variety of smart devices, including smart phones, PCs, and laptops.

4. Data Collection

The objective of this study's data collection is to send questionnaires to some government and private organizations in India. The respondents are mainly involved in the construction of high-rise building projects across the country. A questionnaire survey Google form was distributed across India to 150 construction industry professionals, including Clients/Developers, General Managers, Project Managers, Architects, Structural Consultants, Project

Management Consultants, Project Engineers, and Contractors, and subsequently followed up to obtain responses. After following up, 101 of the 150 responses were received.

Questionnaire characteristics analysis

Since the analysis of this study was based on the data that was gathered from the questionnaire, the analysis began with the characteristics of the respondent. Specifically, after the first section of the questionnaire, which was an introduction, the second section of the questionnaire, which includes 6 parts, was devoted to the respondent's characteristics (general information). Each of these parts was defined and analyzed below.

Part-1: Type of organization

A majority of those who participated were technical professionals like engineers and architects; others were company owners and contractors. The type of organization of the respondents is explained in **Figure 2**.

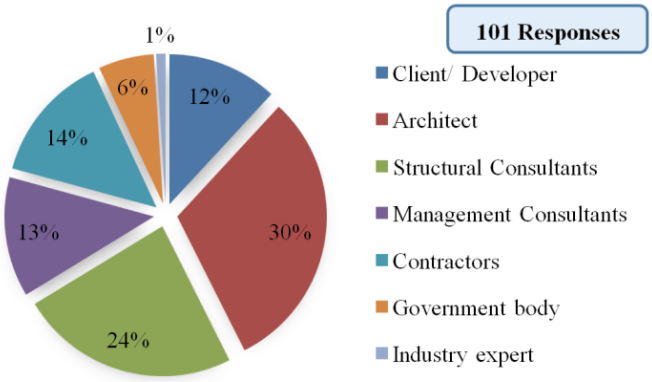

Figure 2. Respondent's organization in pie chart.

Part-2: Organization size

The majority of respondents belong to medium-sized organizations, while the remaining percentage belongs to big and small-sized organizations. For this study, "big-sized organizations" are defined as having yearly revenue of more than Rs.100 Crore. Medium-sized organizations are defined as having annual revenue of between Rs.20 Crore and Rs.100 Crore. The small-sized organizations considered have a turnover of less than Rs.20 Crore per annum. The Organization size of the respondents is explained in **Figure 3**.

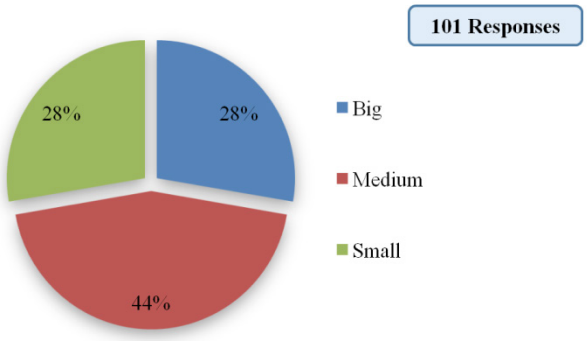

Figure 3. Organization size in bar chart.

Part-3: Respondent's experience

Forty-two respondents had more than 15 years of experience in the construction field, nine had more than 10 years of experience, twenty-four had an average experience of more than 6 years, and twenty-six were newcomers to construction industry. The experience of the respondents is explained in **Figure 4**.

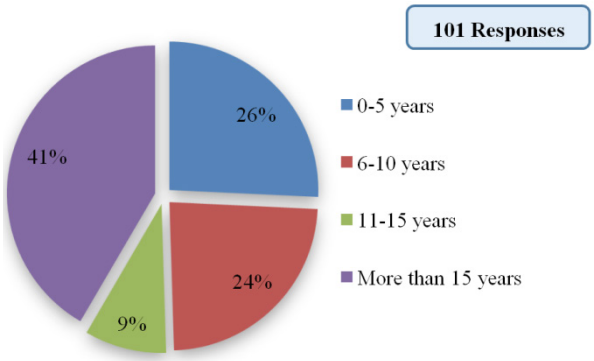

Figure 4. Respondent's experience in pie chart.

Part-4: Respondent's designation

This section of the report provides an analysis of the job titles held by the respondents. A number of the respondents held positions such as Directors, Project Managers, General Managers, Structural Consultants, Architects, P.M. Consultants, and Quantity Surveyors, and some of them were business owners. The position of the respondents is explained in **Figure 5**.

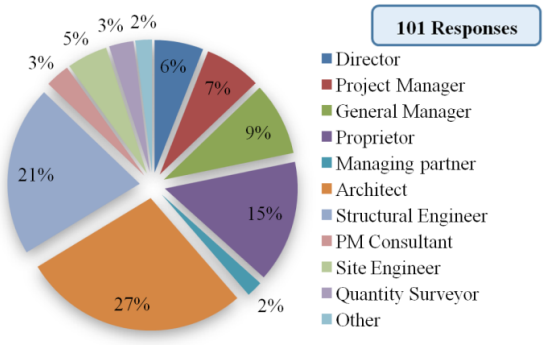

Figure 5. Respondent's designation in pie chart.

Part-5: Respondent's organization location (state)

Most of the respondents are from Telangana State, followed by Maharashtra, Andhra Pradesh, Karnataka, Punjab, Orissa, Delhi, and Tamil Nadu. The organization location of the respondents is explained in **Table 2**.

Table 2. Respondent characteristics by organization location.

State	Percentage of respondent
Telangana	77%
Maharashtra	9%
Andhra Pradesh	5%
Karnataka	3%
Punjab	2%
Orissa	2%
Delhi	1%
Tamil Nadu	1%
Total	100%

Part-6: The number of floors in the tallest building on which respondents have worked so far

In this section of the report, the respondents who worked in the tallest building are described. Of the respondents, 35% had worked up to 10 floors, 23% up to 20 floors, 21% up to 30 floors, 13% up to 40 floors, and the remaining 8% had worked up to and above 50 floors as shown in **Figure 6**.

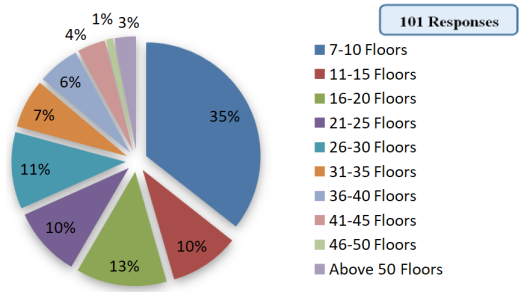

Figure 6. Floors in respondents' tallest building in bar chart.

5. Data analysis

The collected data from Google Forms were studied and ranked using the relative importance index (RII) approach in Microsoft Excel and identified the most critical ones. A total of seventy factors were identified through the study's literature review and expert opinions, and these factors were then divided into seven categories: Estimating and financing, design and contracts, management, construction, materials and equipment, labour, and external related cost-over factors. Spearman's Rank Correlation method was used in SPSS software to check the degree of relationship between the rankings of factors provided by the owner, the consultant, and the contractor. Factor analysis was also used in SPSS to uncover the core components of cost overrun factors and their relationships.

a) Relative importance index (RII) method

To determine the relative importance of the numerous causes of cost overruns, the score for each factor is determined. This is accomplished by summing the scores of all respondents. The relative importance index is calculated using the following equation. In order to analyze the responses, the following number of values were assigned to the respondents' opinions as shown in **Table 3**:

$$\text{Relative Importance Index (RII)} = \frac{\sum_{i=1}^{5} w_i \cdot x_i}{A \times N}$$

where,

RII = relative importance index;

w = weighting given to each factor by respondents and it ranges from 1 to 5;

x = frequency of it response given for each cause;

A = highest weight (i.e. 5 in this case);

N = total number of participants.

Table 3. Numerical values of respondents' opinions.

Opinion	Severity
Strongly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Strongly disagree	1

i) Ranking of cost overrun factors

In this part of the study, the causes that led to cost overruns as rated by survey respondents have been ranked. Each of the seven sub-sections of this study was studied separately, and then ranked using the relative importance index (RII) method and the same was illustrated in **Table 4**.

ii) Ranking of cost overrun factors based on type of organization

In this phase of the study, cost overrun factors have been ranked based on the type of organization using the relative importance index (RII) method. The types of organizations are owner, contractor, and consultant. According to the owners, the top three cost overrun factors are: unforeseen ground conditions; delay in construction; and escalation of material price. According to the contractors, the top 3 cost overrun factors are market inflation or deflation; frequent changes in design; and frequent change orders during construction by the owner. The consultant says that frequent changes made by the owner during construction, delays in construction, and rework are the top three factors of cost overrun. The same is illustrated in **Table 5**.

Table 4. Ranking of cost overrun factors.

Code No.	Factors causing cost overrun	RII	Group ranking	Overall ranking
Part-1: Estimation and Finance-related factors causing cost overrun				
EF-F1	Poor pre-construction budget	0.82	**GR3**	**R12**
EF-F2	Inaccurate quantity take-off	0.82	**GR1**	**R9**
EF-F3	Wrong unit cost of materials	0.74	**GR7**	**R46**
EF-F4	Wrong estimation method	0.71	**GR8**	**R54**
EF-F5	Difficulties in project financing by owner	0.79	**GR5**	**R30**
EF-F6	Delay in progressive payment by owner	0.82	**GR2**	**R10**
EF-F7	Incorrect financial & payment methods from owner site	0.75	**GR6**	**R44**
EF-F8	Poor financial control on site by contractor	0.81	**GR4**	**R14**
Part-2: Design and Contract-related factors causing cost overrun				
DC-F1	Mistakes and errors in design	0.74	**GR8**	**R49**
DC-F2	Frequent changes in design	0.84	**GR1**	**R6**
DC-F3	Delay in approving drawings	0.79	**GR5**	**R29**
DC-F4	Delay in inspection and approval of completed works	0.71	**GR9**	**R56**
DC-F5	Incomplete design at the time of tender	0.79	**GR4**	**R28**
DC-F6	Poor Contract management	0.81	**GR2**	**R19**
DC-F7	Lowest bid win	0.75	**GR6**	**R42**
DC-F8	Contractual claims, such as, extension of time with cost claims by contractor	0.80	**GR3**	**R21**
DC-F9	Mistakes & discrepancies in contract document	0.74	**GR7**	**R47**
Part-3: Management-related factors causing cost overrun				
M-F1	Not conducting feasibility study of the project	0.81	**GR3**	**R15**
M-F2	Poor site management & supervision by contractor	0.81	**GR4**	**R16**
M-F3	Poor project management by PMC (Project management consultant)	0.81	**GR5**	**R20**
M-F4	Inaccurate evaluation of projects timeline	0.83	**GR1**	**R7**
M-F5	Inadequate planning and scheduling	0.82	**GR2**	**R11**
M-F6	Inadequate monitoring the work progress by contractor	0.80	**GR6**	**R24**
M-F7	Lack of cost reports during construction stage	0.75	**GR9**	**R41**
M-F8	Lack of communication & coordination between construction parties	0.78	**GR8**	**R35**
M-F9	Conflict between project parties	0.74	**GR10**	**R48**

Table 4 continued

Code No.	Factors causing cost overrun	RII	Group ranking	Overall ranking
M-F10	Delays in issuing information to the contractor during construction stage	0.79	**GR7**	**R31**
Part-4: Construction-related factors causing cost overrun				
C-F1	Delay in construction	0.86	**GR2**	**R2**
C-F2	Rework	0.85	**GR3**	**R5**
C-F3	Non-performance of subcontractors and selected suppliers	0.78	**GR6**	**R32**
C-F4	Failure to apply safety rules and regulation within the contractor's organization	0.71	**GR10**	**R57**
C-F5	Project size	0.63	**GR13**	**R70**
C-F6	Complexity of Project	0.69	**GR11**	**R64**
C-F7	Mistakes during construction by contractors	0.78	**GR7**	**R34**
C-F8	Frequent change orders during construction by owner	0.86	**GR1**	**R1**
C-F9	Owner interference	0.76	**GR8**	**R39**
C-F10	Work suspension by owner	0.80	**GR5**	**R22**
C-F11	High quality of work required by owner	0.65	**GR12**	**R69**
C-F12	Risk & uncertainty related with projects	0.73	**GR9**	**R50**
C-F13	Poor experience of the contractor	0.82	**GR4**	**R13**
Part-5: Material and Equipment-related factors causing cost overrun				
ME-F1	Shortage of materials in the market	0.76	**GR6**	**R40**
ME-F2	Escalation of material price	0.86	**GR1**	**R3**
ME-F3	Delay in material delivery	0.81	**GR2**	**R17**
ME-F4	Poor material handling on site	0.77	**GR5**	**R37**
ME-F5	Changes in material specification and type	0.80	**GR4**	**R23**
ME-F6	Low quality of materials	0.68	**GR12**	**R66**
ME-F7	Delay in material procurement	0.81	**GR3**	**R18**
ME-F8	Frequent breakdown of construction plants and equipment	0.70	**GR9**	**R61**
ME-F9	High transportation cost	0.73	**GR7**	**R53**
ME-F10	High cost of machinery	0.71	**GR8**	**R55**
ME-F11	Equipment operators skill level is low	0.69	**GR10**	**R62**
ME-F12	High maintenance cost of machinery	0.69	**GR11**	**R65**
Part-6: Labour-related factors causing cost overrun				
L-F1	Lack of safety measures taken by labour	0.73	**GR8**	**R51**
L-F2	Strike	0.69	**GR10**	**R63**
L-F3	Difficulties in monthly payments from agencies	0.80	**GR1**	**R25**
L-F4	High cost of labour	0.74	**GR7**	**R45**
L-F5	Poor labour productivity	0.79	**GR3**	**R27**
L-F6	Lack of adequate manpower	0.78	**GR4**	**R36**
L-F7	Inadequate & insufficient skill of labour	0.80	**GR2**	**R26**
L-F8	Lack of labour training	0.77	**GR5**	**R38**
L-F9	Labour absenteeism	0.75	**GR6**	**R43**
L-F10	Excessive over time	0.70	**GR9**	**R60**
Part-7: External-related factors causing cost overrun				
E-F1	Market inflation/ deflation	0.85	**GR1**	**R4**
E-F2	Unforeseen ground condition	0.82	**GR2**	**R8**

Table 4 continued

Code No.	Factors causing cost overrun	RII	Group ranking	Overall ranking
E-F3	Unpredictable weather conditions	0.78	**GR3**	**R33**
E-F4	Insurance & accidents	0.73	**GR4**	**R52**
E-F5	Corruption	0.71	**GR5**	**R58**
E-F6	Security problems	0.67	**GR8**	**R68**
E-F7	Problems with neighbours	0.68	**GR7**	**R67**
E-F8	Difficulties in importing equipment and materials	0.71	**GR6**	**R59**

Table 5. Ranking of factors based on type of organization.

Code No.	Factors Causing Cost Overrun	Overall		Owner		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
C-F8	Frequent change orders during construction by owner	**1**	0.86	0.82	7	0.94	3	0.86	1
C-F1	Delay in construction	**2**	0.86	0.84	2	0.93	6	0.84	2
ME-F2	Escalation of material price	**3**	0.86	0.84	3	0.94	4	0.84	4
E-F1	Market inflation/deflation	**4**	0.85	0.84	4	0.96	1	0.83	7
C-F2	Rework	**5**	0.85	0.80	15	0.93	7	0.84	3
DC-F2	Frequent changes in design	**6**	0.84	0.81	11	0.94	2	0.83	9
M-F4	Inaccurate evaluation of projects timeline	**7**	0.83	0.80	14	0.84	24	0.83	5
E-F2	Unforeseen ground condition	**8**	0.82	0.86	1	0.89	18	0.80	23
EF-F2	Inaccurate quantity take-off	**9**	0.82	0.79	19	0.91	8	0.81	17
EF-F6	Delay in progressive payment by owner	**10**	0.82	0.82	5	0.91	9	0.80	22
M-F5	Inadequate planning and scheduling	11	0.82	0.81	12	0.86	21	0.82	12
EF-F1	Poor pre-construction budget	12	0.82	0.79	18	0.89	15	0.81	14
C-F13	Poor experience of the contractor	13	0.82	0.79	21	0.80	36	0.83	6
EF-F8	Poor financial control on site by contractor	14	0.81	0.78	23	0.79	39	0.83	8
M-F1	Not conducting feasibility study of the project	15	0.81	0.76	28	0.91	12	0.81	19
M-F2	Poor site management & supervision by contractor	16	0.81	0.74	33	0.84	23	0.82	10
ME-F3	Delay in material delivery	17	0.81	0.78	24	0.94	5	0.79	29
ME-F7	Delay in material procurement	18	0.81	0.79	22	0.91	13	0.79	27
DC-F6	Poor contract management	19	0.81	0.76	27	0.83	29	0.81	15
M-F3	Poor project management by PMC (Project management consultant)	20	0.81	0.74	34	0.81	32	0.82	11
DC-F8	Contractual claims, such as, extension of time with cost claims by contractor	21	0.80	0.79	20	0.91	11	0.79	30
C-F10	Work suspension by owner	22	0.80	0.81	13	0.83	30	0.80	25
ME-F5	Changes in material specification and type	23	0.80	0.76	31	0.84	25	0.81	21
M-F6	Inadequate monitoring the work progress by contractor	24	0.80	0.76	29	0.79	40	0.81	16
L-F3	Difficulties in monthly payments from agencies	25	0.80	0.82	8	0.87	19	0.78	34
L-F7	Inadequate & insufficient skill of labour	26	0.80	0.80	16	0.77	49	0.80	24
L-F5	Poor labour productivity	27	0.79	0.74	36	0.84	26	0.80	26
DC-F5	Incomplete design at the time of tender	28	0.79	0.77	25	0.83	28	0.79	28
DC-F3	Delay in approving drawings	29	0.79	0.82	6	0.89	17	0.76	37
EF-F5	Difficulties in project financing by owner	30	0.79	0.81	10	0.89	16	0.76	38

Table 5 continued

Code No.	Factors Causing Cost Overrun	Overall		Owner		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
M-F10	Delays in issuing information to the contractor during construction stage	31	0.79	0.68	55	0.77	45	0.82	13
C-F3	Non-performance of subcontractors and selected suppliers	32	0.78	0.73	39	0.73	54	0.81	18
E-F3	Unpredictable weather conditions	33	0.78	0.82	9	0.86	22	0.76	41
C-F7	Mistakes during construction by contractors	34	0.78	0.72	42	0.73	55	0.81	20
M-F8	Lack of communication & coordination between construction parties	35	0.78	0.76	30	0.80	35	0.78	33
L-F6	Lack of adequate manpower	36	0.78	0.74	37	0.77	48	0.79	31
ME-F4	Poor material handling on site	37	0.77	0.71	45	0.79	42	0.78	32
L-F8	Lack of labour training	38	0.77	0.73	40	0.77	50	0.77	35
C-F9	Owner interference	39	0.76	0.68	57	0.90	14	0.76	42
ME-F1	Shortage of materials in the market	40	0.76	0.77	26	0.73	57	0.77	36
M-F7	Lack of cost reports during construction stage	41	0.75	0.73	38	0.79	41	0.75	43
DC-F7	Lowest bid win	42	0.75	0.72	41	0.91	10	0.72	55
L-F9	Labour absenteeism	43	0.75	0.71	47	0.79	43	0.75	44
EF-F7	Incorrect financial & payment methods from owner site	44	0.75	0.74	32	0.80	34	0.74	49
L-F4	High cost of labour	45	0.74	0.70	52	0.87	20	0.73	54
EF-F3	Wrong unit cost of materials	46	0.74	0.71	43	0.80	33	0.74	48
DC-F9	Mistakes & discrepancies in contract document	47	0.74	0.68	54	0.73	53	0.76	39
M-F9	Conflict between project parties	48	0.74	0.71	44	0.69	58	0.76	40
DC-F1	Mistakes and errors in design	49	0.74	0.70	49	0.77	44	0.74	46
C-F12	Risk & uncertainty related with projects	50	0.73	0.67	60	0.77	46	0.74	47
L-F1	Lack of safety measures taken by labour	51	0.73	0.66	62	0.80	37	0.74	50
E-F4	Insurance & accidents	52	0.73	0.68	58	0.80	38	0.73	52
ME-F9	High transportation cost	53	0.73	0.70	51	0.83	31	0.72	57
EF-F4	Wrong estimation method	54	0.71	0.70	48	0.74	52	0.71	58
ME-F10	High cost of machinery	55	0.71	0.74	35	0.77	47	0.70	65
DC-F4	Delay in inspection and approval of completed works	56	0.71	0.70	50	0.83	27	0.69	66
C-F4	Failure to apply safety rules and regulation within the contractor's organization	57	0.71	0.66	61	0.69	59	0.73	51
E-F5	Corruption	58	0.71	0.68	59	0.60	68	0.74	45
E-F8	Difficulties on importing equipment and materials	59	0.71	0.80	17	0.60	69	0.71	60
L-F10	Excessive Over time	60	0.70	0.57	70	0.77	51	0.72	56
ME-F8	Frequent breakdown of construction plants and equipment	61	0.70	0.64	64	0.61	66	0.73	53
ME-F11	Equipment operators' skill level is low	62	0.69	0.71	46	0.59	70	0.71	61
L-F2	Strike	63	0.69	0.66	63	0.67	61	0.71	62
C-F6	Complexity of project	64	0.69	0.68	56	0.69	60	0.69	67
ME-F12	High maintenance cost of machinery	65	0.69	0.63	65	0.66	62	0.70	64
ME-F6	Low quality of materials	66	0.68	0.62	67	0.61	65	0.71	59
E-F7	Problems with neighbours	67	0.68	0.63	66	0.63	64	0.71	63
E-F6	Security problems	68	0.67	0.69	53	0.61	67	0.68	68

Table 5 continued

Code No.	Factors Causing Cost Overrun	Overall		Owner		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
C-F11	High quality of work required by owner	69	0.65	0.60	69	0.73	56	0.64	69
C-F5	Project size	70	0.63	0.61	68	0.63	63	0.64	70

b) Spearman's rank correlation test

Two ranked variables may be compared using Spearman's rank correlation to determine their correlation strength and direction. It simply determines how effectively the connection between two variables can be represented by a monotonic function, which is another way of saying that it provides a measure of the monotonicity of the relation between the two variables. The degree of correlation is illustrated in **Figure 7**.

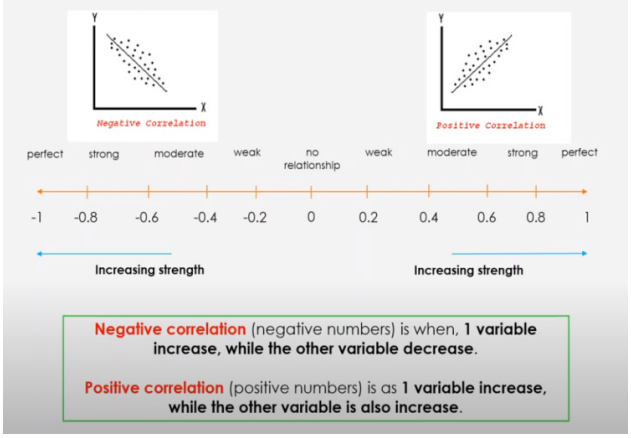

Figure 7. Degree of correlation.

The Spearman Coefficient, denoted by the symbol ρ, may have a value anywhere from +1 to –1, with the following consequences:

A ρ value of +1 indicates a perfect relationship of rank.

A ρ value of 0 indicates that there is no relationship between ranks.

A ρ value of –1 indicates a negative relationship between ranks.

The closer the ρ value to 0, the weaker is the relationship between the two ranks.

The closer the ρ value to 1, the stronger is the relationship between the two ranks.

The statistical tool Spearman's coefficient of rank correlation was used to check the degree of relationship between the rankings of the groups of respondents, namely contractors, consultants, and owners, in SPSS software.

Table 6. Spearman's rank correlation result.

	Spearman's rank correlation coefficient	Significance level
Owners—Contractors	0.709**	< 0.001
Owners—Consultants	0.724**	< 0.001
Contractors—Consultants	0.630**	< 0.001

Correlation is significant at the 0.01 ** level (2-tailed).

Table 6 illustrates the results of Spearman coefficient and significance level calculations. In spite of the amount of correlation, one may draw the conclusion from these data that there is a very significant relationship between the rankings of factors provided by the owner, the consultant, and the contractor. The degree of relationship between owners and contractors is the highest (about 71 percent). The degree of relationship between owners and consultants is the highest (about 72 percent) and the degree of relationship between contractors and consultants is the lowest (about 63 percent). All data may be used as a whole for further research due to the strong relationship among parties in ranking factors of cost overruns.

c) Reliability analysis

Multiple-scale data may be checked for internal consistency using a method called reliability analysis. Several different reliability coefficients may be calculated in order to conduct a reliability test, but the most popular is called Cronbach's alpha. If the Cronbach's alpha for your data is less than 0.3, the data is not reliable enough to use in your analysis. If it is more than 0.7, then, you may proceed with confidence. **Table 7** illustrates the results of reliability analysis.

Table 7. Reliability statistics.

Cronbach's alpha	Cronbach's alpha based on standardized items	N of items
0.965	0.966	70

Cronbach's alpha was calculated for the factors using the SPSS software to ensure the consistency of the results. Cronbach's alpha for cost overrun factors was 0.965, beyond the threshold of statistical significance (alpha = 0.7). Therefore, the data gathered from respondents was valid and usable.

d) Factor analysis

Factor analysis is a data reduction technique that helps narrow down a vast set of potential factors to a smaller set. It is a good tool for studying the relationships between components in complex notions.

For the purpose of determining the factor structure and the degree of correlation that exists between the various components of the scale, an exploratory factor analysis employing the maximum likelihood method with Varimax rotation is carried out. Following are tables containing the outcomes of the rotated factor matrix. Initially the desire results were not obtained as one of the items was cross loading on two different component factors. The item (DC-F3"Delayin approvingdrawings")was removed and get the following final result.

It is important to verify the data's eligibility before using this method. In this sense, the significance of Barlett's test of sphericity (usually less than 0.05) suggests that the correlation matrix is not an identity matrix. If the result of Kaiser-Meyer-sampling Olkin's adequacy test is more than 0.5, the sample is considered to be adequately representative. These two conditions ensure the suitability of data for proceeding with factor analysis.

i) KMO and Bartlett's test

The data's feasibility for Factor Analysis is determined using the Kaiser-Meyer-Olkin (KMO) Test. The test examines how well each model variable and the whole model are sampled. The similarity between variables is measured by this statistic, which expresses the percentage of that variance that may be shared.

In **Table 8**, the Kaiser-Meyer-Olkin (KMO) index of sample adequacy was determined to be 0.747, which was greater than 0.50. This was considered to be significant. The fact that the matrix was able to pass the test of identity was further supported by the fact that the significance level for the Bartlett test was set at 0.001, which is lower than 0.05. These measurements confirmed that the data was appropriate for factor analysis.

Table 8. KMO and Bartlett's test result.

Kaiser-Meyer-Olkin Measure of sampling adequacy		0.747
Bartlett's test of sphericity	Approx. Chi-Square	5435.397
	df	2346
	Sig.	< 0.001

Table 9. Communalities.

S. No.	Factor	Initial	Extraction
1	Poor pre-construction budget	1.000	0.729
2	Inaccurate quantity take-off	1.000	0.786
3	Wrong unit cost of materials	1.000	0.734
4	Wrong estimation method	1.000	0.761
5	Difficulties in project financing by owner	1.000	0.811
6	Delay in progressive payment by owner	1.000	0.788
7	Incorrect financial & payment methods from owner site	1.000	0.693
8	Poor financial control on site by contractor	1.000	0.769
9	Mistakes and errors in design	1.000	0.728
10	Frequent changes in design	1.000	0.782
11	Delay in inspection and approval of completed works	1.000	0.729
12	Incomplete design at the time of tender	1.000	0.771
13	Poor contract management	1.000	0.700

Table 9 continued

S. No.	Factor	Initial	Extraction
14	Lowest bid win	1.000	0.700
15	Contractual claims, such as, extension of time with cost claims by contractor	1.000	0.664
16	Mistakes & discrepancies in contract document	1.000	0.639
17	Not conducting feasibility study of the project	1.000	0.775
18	Poor site management & supervision by contractor	1.000	0.812
19	Poor project management by PMC	1.000	0.744
20	Inaccurate evaluation of projects timeline	1.000	0.696
21	Inadequate planning and scheduling	1.000	0.733
22	Inadequate monitoring the work progress by contractor	1.000	0.737
23	Lack of cost reports during construction stage	1.000	0.650
24	Lack of communication & coordination between construction parties	1.000	0.759
25	Conflict between project parties	1.000	0.654
26	Delays in issuing information to the contractor during construction stage	1.000	0.678
27	Delay in construction	1.000	0.801
28	Rework	1.000	0.717
29	Non-performance of subcontractors and selected suppliers	1.000	0.699
30	Failure to apply safety rules and regulation within the contractor's organization	1.000	0.740
31	Project size	1.000	0.769
32	Complexity of project	1.000	0.802
33	Mistakes during construction by contractors	1.000	0.744
34	Frequent change orders during construction by owner	1.000	0.848
35	Owner interference	1.000	0.838
36	Work suspension by owner	1.000	0.781
37	High quality of work required by owner	1.000	0.714
38	Risk & uncertainty related with projects	1.000	0.737
39	Poor experience of the contractor	1.000	0.724
40	Shortage of materials in the market	1.000	0.608
41	Escalation of material price	1.000	0.817
42	Delay in material delivery	1.000	0.712
43	Poor material handling on site	1.000	0.733
44	Changes in material specification and type	1.000	0.768
45	Low quality of materials	1.000	0.685
46	Delay in material procurement	1.000	0.765
47	Frequent breakdown of construction plants and equipment	1.000	0.796
48	High transportation cost	1.000	0.778
49	High cost of machinery	1.000	0.794
50	Equipment operators skill level is low	1.000	0.826
51	High maintenance cost of machinery	1.000	0.736
52	Lack of safety measures taken by labour	1.000	0.692
53	Strike	1.000	0.794
54	Difficulties in monthly payments from agencies	1.000	0.635
55	High cost of labour	1.000	0.776
56	Poor labour productivity	1.000	0.784

Table 9 continued

S. No.	Factor	Initial	Extraction
57	Lack of adequate manpower	1.000	0.773
58	Inadequate & insufficient skill of labour	1.000	0.815
59	Lack of labour training	1.000	0.781
60	Labour absenteeism	1.000	0.641
61	Excessive over time	1.000	0.819
62	Market inflation/deflation	1.000	0.771
63	Unforeseen ground condition	1.000	0.800
64	Unpredictable weather conditions	1.000	0.780
65	Insurance & accidents	1.000	0.709
66	Corruption	1.000	0.785
67	Security problems	1.000	0.805
68	Problems with neighbours	1.000	0.756
69	Difficulties in importing equipment and materials	1.000	0.781

ii) Communalities

In **Table 9**, the communalities are all more than 0.5, indicating some variation across all the components. Based on the results of the aforementioned research, all of the items (69) are suitable for the analysis. Since one of the main objectives of the study was to determine the core components of cost overruns factors in the Indian construction industry, the principle component technique was used.

iii) Extraction of Factors

Factor extraction was performed using Principal Component Analysis (PCA) in the SPSS software. The main idea behind Principal Component Analysis (PCA) is that the extracted components explain most of the variation between the correlated variables.

Table 10 shows the total number of factors that may be retrieved from the initial solution and the rotated solution, together with their Eigen values, percentages of variance, and cumulative percentages of variation. A component having an Eigen value less than one was deemed less relevant and may therefore be disregarded.

Using the initial statistics of total variance to account for cost overruns, sixteen components with Eigen values greater than 1 were identified as accounting for 74.86% of the overall variation.

iv) Scree plot

The Eigen values are shown in a Scree plot (quality scores). It is shown in **Figure 8** that the Eigen values of the first 16 components are above 1. We give these "strong factors" consideration. The Eigen values drastically decrease from component 17 onward. It is clear from the sharp decline between components 1 to 16 and components 17 to 69 that 16 factors underpin our research questions.

Table 10. Total variance explained.

Component	Initial Eigen values			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	21.104	30.586	30.586	6.490	9.406	9.406
2	5.356	7.763	38.349	3.947	5.720	15.126
3	2.874	4.165	42.514	3.593	5.208	20.334
4	2.662	3.858	46.372	3.566	5.168	25.502
5	2.532	3.670	50.041	3.529	5.115	30.618
6	2.258	3.272	53.313	3.496	5.066	35.684
7	2.097	3.039	56.352	3.394	4.919	40.603
8	1.897	2.749	59.101	3.307	4.792	45.395

Table 10 continued

Component	Initial Eigen values			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
9	1.688	2.447	61.548	3.188	4.621	50.016
10	1.582	2.293	63.841	3.092	4.481	54.497
11	1.503	2.178	66.019	2.924	4.237	58.734
12	1.443	2.091	68.110	2.681	3.885	62.619
13	1.312	1.902	70.012	2.366	3.429	66.047
14	1.204	1.745	71.758	2.347	3.402	69.450
15	1.094	1.586	73.344	2.247	3.256	72.705
16	1.044	1.514	74.857	1.485	2.152	74.857

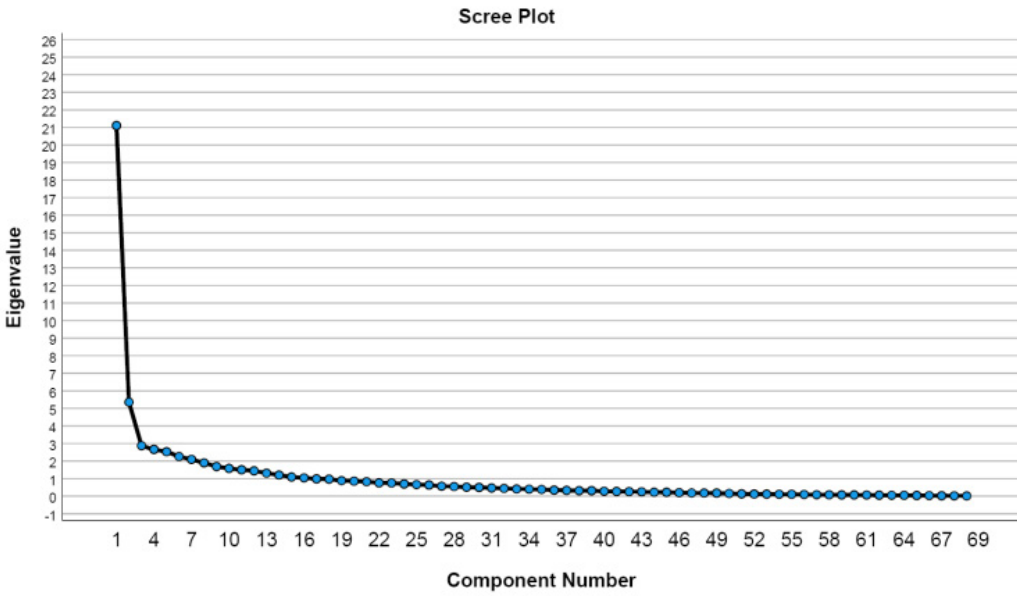

Figure 8. Scree plot of factors.

v) Rotation of matrix

To get easily grasped factor loadings, a Varimax rotation was conducted on the factors to restrict the number of factors with high loading. The Kaiser-Varimax rotation, or Varimax rotation for short, maximizes the total squared variance of the loadings, where loadings refer to the degree to which two variables or factors are correlated. As a consequence, the factor loadings for a subset of the variables will tend to be high while those for the other variables will tend to be low. The Eigen values of the remaining components were all greater than one. In other words, this means that just a few of key factors are emphasized, making your findings simpler to grasp.

Table 11 shows the sixteen core components with factor loadings greater than 0.5, determined using the factor analysis technique. Since the loadings on the other cost overrun factors were below 0.5, they were disregarded. In this study, factors are clustered using the Varimax orthogonal rotation of principal component analysis. Each component's name was suggested based on the unique properties of the factors included in each component. **Table 13** shows the component factors arising from variable grouping using rotation, where CF stands for "component factor".

vi) Correlation matrix of variables

Table 12 shows the correlation matrix for cost overrun factors derived from the IBM SPSS software. All of the correlation values are less than 0.3, indicating that the component factors do not correlate significantly. This confirms that the VERIMAX

orthogonal method is appropriate for this data factor analysis.

Results of factor analysis

The proposed component names are based on the unique properties of the underlying variables. From **Table 13**, we can see that the components are labeled as "Site-specific issues", "Owner's financial capability", "Management related", "Incompetence", "Lack of experience", "Owner involvement", "Project related", "Contractor control", "Estimation related", "Equipment related", "Lack of constraint", "Labour related", "Contractor's financial control", "Other factors", "Market related", and "Productivity". This is crucial, especially if further research is to be performed on the components that have been extracted.

Table 11. Factor analysis loading results.

Factors of cost overruns	**Component**															
	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	CF9	CF10	CF11	CF12	CF13	CF14	CF15	CF16
Problems with neighbours	0.780															
Difficulties in importing equipment and materials	0.741															
Security problems	0.730															
Corruption	0.719															
Low quality of materials	0.669															
Equipment operators skill level is low	0.619															
Difficulties in project financing by owner		0.784														
Delay in progressive payment by owner		0.740														
Delay in material delivery		0.592														
Incorrect financial & payment methods from owner site		0.514														
Poor project management by PMC			0.691													
Not conducting feasibility study of the project			0.668													

Table 11 continued

Factors of cost overruns	**Component**															
	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	CF9	CF10	CF11	CF12	CF13	CF14	CF15	CF16
Poor site management & supervision by contractor			0.666													
Inadequate planning and scheduling			0.584													
Lack of labour training				0.751												
Inadequate & insufficient skill of labour				0.688												
Lack of adequate manpower				0.560												
Delay in material procurement				0.540												
Rework					0.581											
Incomplete design at the time of tender					0.577											
Mistakes & discrepancies in contract document					0.542											
Frequent change orders during construction by owner						0.824										
Owner interference						0.745										
Work suspension by owner						0.510										
Project size							0.782									
Complexity of project							0.715									
High quality of work required by owner							0.539									
Lack of cost reports during construction stage								0.660								
Inadequate monitoring the work progress by contractor								0.555								

Table 11 continued

Factors of cost overruns	**Component**															
	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	CF9	CF10	CF11	CF12	CF13	CF14	CF15	CF16
Wrong estimation method									0.746							
Inaccurate quantity take-off									0.695							
Wrong unit cost of materials									0.661							
Poor pre-construction budget									0.597							
High transportation cost										0.727						
High cost of machinery										0.662						
High maintenance cost of machinery										0.605						
Unpredictable weather conditions											0.757					
Unforeseen ground condition											0.683					
High cost of labour												0.738				
Poor labour productivity												0.594				
Poor financial control on site by contractor													0.737			
Strike														0.649		
Poor contract management														0.577		
Market inflation/ deflation															0.760	
Changes in material specification and type															0.532	
Excessive over time																0.554

Table 12. Correlation matrix of variables.

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	CF9	CF10	CF11	CF12	CF13	CF14	CF15	CF16
CF1	1.00															
CF2	–0.13	1.00														
CF3	0.18	–0.01	1.00													
CF4	–0.09	0.01	–0.15	1.00												
CF5	0.15	–0.06	0.11	–0.17	1.00											
CF6	–0.13	–0.02	–0.03	0.12	–0.08	1.00										
CF7	–0.20	0.20	–0.18	0.12	–0.15	0.03	1.00									
CF8	0.12	0.00	0.19	–0.25	0.19	–0.11	–0.13	1.00								
CF9	0.17	-0.10	0.13	–0.12	0.18	–0.10	–0.14	0.15	1.00							
CF10	–0.01	0.17	0.00	0.03	0.04	0.00	0.09	–0.02	–0.02	1.00						
CF11	0.08	–0.16	0.05	–0.15	0.19	–0.05	–0.18	0.15	0.14	–0.08	1.00					
CF12	0.18	–0.05	0.18	–0.23	0.17	–0.13	–0.20	0.18	0.27	0.01	0.18	1.00				
CF13	0.12	–0.03	0.17	–0.22	0.11	–0.08	–0.03	0.16	0.12	–0.01	0.14	0.16	1.00			
CF14	0.17	–0.22	0.13	–0.13	0.16	–0.11	–0.30	0.10	0.10	–0.07	0.20	0.10	0.06	1.00		
CF15	0.18	–0.18	0.13	–0.13	0.06	–0.06	–0.21	0.19	0.16	–0.10	0.22	0.23	0.12	0.12	1.00	
CF16	0.20	–0.23	0.09	–0.11	0.20	–0.07	–0.21	0.04	0.19	–0.11	0.27	0.22	0.15	0.21	0.19	1.00

**Correlation is significant at the 0.05 level (2-tailed).

Table 13. Factor categories using factor analysis.

Component factor	Cost overruns causing due to…	Component name
CF1	Problems with neighbours Difficulties in importing equipment and materials Security problems, Corruption Low quality of materials Equipment operators skill level is low	Site-specific issues
CF2	Difficulties in project financing by owner Delay in progressive payment by owner Delay in material delivery Incorrect financial & payment methods from owner site	Owner's financial capability
CF3	Poor project management by PMC Not conducting feasibility study of the project Poor site management & supervision by contractor Inadequate planning and scheduling	Management related
CF4	Lack of labour training Inadequate & insufficient skill of labour Lack of adequate manpower Delay in material procurement	Incompetence
CF5	Rework Incomplete design at the time of tender Mistakes & discrepancies in contract document	Lack of experience
CF6	Frequent change orders during construction by owner Owner interference Work suspension by owner	Owner involvement
CF7	Project size Complexity of project High quality of work required by owner	Project related

Table 13 continued

Component factor	Cost overruns causing due to…	Component name
CF8	Lack of cost reports during construction stage Inadequate monitoring the work progress by contractor	Contractor control
CF9	Wrong estimation method Inaccurate quantity take-off Wrong unit cost of materials Poor pre-construction budget	Estimation related
CF10	High transportation cost High cost of machinery High maintenance cost of machinery	Equipment related
CF11	Unpredictable weather conditions Unforeseen ground condition	Lack of constraint
CF12	High cost of labour Poor labour productivity	Labour related
CF13	Poor financial control on site by contractor	Contractor's financial control
CF14	Strike Poor contract management	Other factors
CF15	Market inflation/deflation Changes in material specification and type	Market related
CF16	Excessive over time	Productivity

6. Findings & discussion

This part will describe the data that was analyzed from the survey. The results will be assessed and discussed separately for each of the seven categories of factors that cause cost overruns, taking into account the three highest-ranked and three lowest-ranked factors in each category. The main goal of the research was to identify the ten most significant causes of cost overruns in high-rise building construction projects in India.

Construction cost overrun factors analysis

The questionnaire survey consisted of seven sections, each of which was studied and discussed separately, taking into account the three highest and lowest causes of cost overruns.

i. Estimation and finance related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 8 factors, the three highest-ranking factors that cause cost overruns because of estimation and finance problems are as follows:

- Inaccurate quantity take-off (Rank No.1)
- Delay in progressive payment by owner (Rank No.2)
- Poor pre-construction budget (Rank No.3)

In addition, the following three factors, out of a total of eight that are related to estimation and finance, have the lowest ranking:

- Wrong estimation method (Rank No.8)
- Wrong unit cost of materials (Rank No.7)
- Incorrect financial & payment methods from owner site (Rank No.6)

ii. Design and contract related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 9 factors, the three highest-ranking factors that cause cost overruns because of design and contract problems are as follows:

- Frequent changes in design (Rank No.1)
- Poor contract management (Rank No.2)
- Contractual claims, such as, extension of time with cost claims by contractor (Rank No.3)

In addition, the following three factors, out of a total of nine that are related to design and contract, have the lowest ranking:

- Delay in inspection and approval of completed works (Rank No.9)
- Mistakes and errors in design (Rank No.8)
- Mistakes & discrepancies in contract document (Rank No.7)

iii. Management related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 10 factors, the three highest-ranking factors that cause cost overruns because of management problems are as follows:

• Inaccurate evaluation of projects timeline (Rank No.1)

• Inadequate planning and scheduling (Rank No.2)

• Not conducting feasibility study of the project (Rank No.3)

In addition, the following three factors, out of a total of ten that are related to management, have the lowest ranking:

• Conflict between project parties (Rank No.10)

• Lack of cost reports during construction stage (Rank No.9)

• Lack of communication & coordination between construction parties (Rank No.8)

iv. Construction related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 13 factors, the three highest-ranking factors that cause cost overruns because of construction problems are as follows:

• Frequent change orders during the construction by owner (Rank No.1)

• Delay in construction (Rank No.2)

• Rework (Rank No.3)

In addition, the following three factors, out of a total of thirteen that are related to construction, have the lowest ranking:

• Project size (Rank No.13)

• High quality of work required by owner (Rank No.12)

• Complexity of project (Rank No.11)

v. Material and equipment related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 12 factors, the three highest-ranking factors that cause cost overruns because of material and equipment problems are as follows:

• Escalation of material price (Rank No.1)

• Delay in material delivery (Rank No.2)

• Delay in material procurement (Rank No.3)

In addition, the following three factors, out of a total of twelve that are related to material and equipment, have the lowest ranking:

• Low quality of materials (Rank No.12)

• High maintenance cost of machinery (Rank No.11)

• Equipment operator's skill level is low (Rank No.10)

vi. Labour related cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 10 factors, the three highest-ranking factors that cause cost overruns because of labour problems are as follows:

• Difficulties in monthly payments from agencies (Rank No.1)

• Inadequate & insufficient skill of labour (Rank No.2)

• Poor labour productivity (Rank No.3)

In addition, the following three factors, out of a total of ten that are related to labour, have the lowest ranking:

• Strike (Rank No.10)

• Excessive over time (Rank No.9)

• Lack of safety measures taken by labour (Rank No.8)

vii. External cost overrun factors

Based on the summary of data analysis shown in **Table 4**, it can be said that out of 8 factors, the three highest-ranking factors that cause cost overruns because of external problems are as follows:

• Market inflation/deflation (Rank No.1)

• Unforeseen ground condition (Rank No.2)

• Unpredictable weather conditions (Rank No.3)

In addition, the following three factors, out of a total of eight that are related to external, have the lowest ranking:

• Security problems (Rank No.8)

• Problems with neighbours (Rank No.7)

• Difficulties in importing equipment and materials (Rank No.6)

Summary of findings

This findings summary was compiled from all over the ranking of cost overrun factors, summariz-

ing the top ten critical factors influencing cost overruns in the construction of high-rise building projects as shown in **Table 14**.

Table 14. List of top critical cost overrun factors in high-rise building project.

Critical factors of cost overrun	Category	RII	Rank
Frequent change orders during construction by owner	Construction	0.861	1
Delay in construction	Construction	0.855	2
Escalation of material price	Material and Equipment	0.855	3
Market inflation/deflation	External	0.850	4
Rework	Construction	0.848	5
Frequent changes in design	Design and Contract	0.840	6
Inaccurate evaluation of projects timeline	Management	0.830	7
Unforeseen ground condition	External	0.824	8
Inaccurate quantity take-off	Estimation and Finance	0.822	9
Delay in progressive payment by owner	Estimation and Finance	0.821	10

7. Experts Review

Experts particulars

After identifying the top ten critical factors, experts from various construction firms were consulted to acquire their recommendations for reducing the re-occurrence of critical factors. A formal opinion request letter and a form to be filled out are presented to them, together with an explanation of my complete research project. Ten factors' opinions were collected from five different experts, with each expert providing an opinion on 2 factors. They have between 25 and 37 years of experience in the construction industry.

Experts suggestions for top 10 critical factors of cost overrun

The experts were requested to write down the likely root causes and also solutions to reduce the re-occurrence of critical factors, and their recommendations have been explained below.

Factor-1: Frequent change orders during construction by owner

√ *Root causes of the factor*

It is usually observed that the owner keeps on changing the plan or taking time to finalize some issues to complete the project. They keep some of the items pending to decide it at later stage, which in turn causes cost overrun in the project.

√ *Solution to avoid the above factor*

Before the onset of the project, client/owner shall study the project and finalize all the drawings by keeping in mind all the requirements of the project and ensuring that the project drawings are completed in all respects and freeze with zero tolerance of any changes to ensure that delay in project will in turn cause project cost overrun.

Factor-2: Delay in construction

√ *Root causes of the factor*

The main cause of construction delays is that work schedules are not prepared and monitored on a weekly basis. As a result, the contractor and client are unaware of the current status of the project, and the work is still unfinished at the end of the estimated time.

The second cause of delays is that clients don't have enough financial backup. This results in unpaid invoices, which force the contractor to halt working.

√ *Solution to avoid the above factor*

The scheduling of the project needs to be done in two distinct ways: first, it needs to be done on a weekly basis so that the progress of the project can be monitored in a close manner; and second, it needs to be done by PMC experts who have site-specific practical experience. Doing these two things will ensure that any potential delays in the project are taken into account and that the schedule will be as accurate as possible.

The next solution is that the client should have sufficient bank money, which must be released in accordance with the progress of the work. The client is required to prepare cash flows and manage available finances in line with them. A fund being released on time is better than having funds in the bank.

Factor-3: Escalation of material price

√ *Root causes of the factor*

There are many factors that cause the escalation of material prices like new taxes levied, currency variations, shipping costs, warehousing costs, changes in prices of

raw material and additional rules to be followed.

√ *Solution to avoid the above factor*

A price escalation clause should be requested when creating new construction contracts. A price escalation clause must establish a base price and the contract's bid price in order to be effective. An agreement that protects both contractors and owners must be included by raising the baseline price in the event of cost increases and by dropping the baseline price in the event of cost declines.

Price increases and decreases should be based on an agreed-upon index, such as Producer Price Index (PPI), which should be stated in the price escalation clause. This index should be established at the contract formation stage. Working with an attorney is essential for both contractors and owners to make sure that their price escalation clauses are both enforceable and equitable for all parties involved.

Factor-4: Market inflation/deflation

√ *Root causes of the factor*

Inflation poses a serious risk for the construction industry since it drives up the price of construction materials, equipment rentals, expert fees, and other inputs. Therefore, it may prolong the duration of the project, increase the total cost of construction, and reduce the project's potential for profit.

√ *Solution to avoid the above factor*

• When submitting a bid, be sure you have exact quantities on hand. In addition, contractors should utilize the projected input price that is predicted when the project begins rather than when the bid is being created.

• Review project costs regularly to stay on budget. Modifications must be done when an issue arises. Owners and developers should implement 10 to 12 percent annual escalation contingencies due to greater budgetary buffers for cost overruns.

• Inflation doesn't affect all materials equally. Some materials see greater price increases. Similar strength and design can be achieved with less expensive materials.

• Lean construction practices save money, optimize project efficiency and reduce waste during construction.

• Order construction materials in advance to avoid price hikes and inflation.

• Instead of the lowest bid, Focus on non-monetary value i.e. experience, speed, and quality.

Factor-5: Rework

√ *Root causes of the factor*

• Rework is a regular phenomenon in the construction of high-rise especially in the finishing stage.

• The repeated work happens in laying of flooring

  ▪ Marble getting stained because of negligence

  ▪ Tiles having improper joints/improper grouts leading to leakage and rework

  ▪ Bad workmanship of the tile layer.

• Improper waterproofing work sometimes causes rework and results in cost overruns.

• Not checking the pipes with pressure test leads to leakage which further leads to breaking the tiles/plaster and changing of pipes which are huge in cost.

• Rework occurs when work is done without following approved drawings and notifying supervisors/engineers.

√ *Solution to avoid the above factor*

The occurrence of rework may be greatly reduced by employing adequate and experienced technical employees to undertake the job. If new employees are employed, they must get sufficient training and work under the supervision of experienced employees for a period of time until they achieve precision in their job.

All agencies engaged in the project must work together to ensure adequate coordination. If information is not delivered at the appropriate moment, a mistake occurs, and rework is required.

Factor-6: Frequent changes in design

√ *Root causes of the factor*

• This happens in apartment houses because of the interpretation of Vastu (especially in Telugu states) which leads to the breaking of walls, shifting doors, windows etc., which leads to cost overruns.

• In office/commercial buildings, buyers demanding change in layout, additional requirement leads to cost overruns.

• Also from family friends and consultants, mak-

ing changes also lead to cost overrun.

√ *Solution to avoid the above factor*

• The client must provide his entire requirement at the time of the initial design stage, so that architects may design with the client's requirements in mind. This design drawing must be approved by other consultants such as structural, MEP, and others.

• If the client or consultants want any revisions, the architect should be informed before the design drawings are completed.

• In the case of high-rise residences or commercial buildings, the client must interact with buyers to learn about their needs and preferences. As a result, it will aid the architect in creating a proper design.

• If the client/buyer is concerned about Vastu, they must notify the architect; otherwise, significant changes will be made afterward.

• Once the design drawings have been approved by the client and consultants, they should be frozen and no further modifications should be made.

Factor-7: Inaccurate evaluation of projects timeline

√ *Root causes of the factor*

Contractors set unrealistic project deadlines when they don't evaluate the strength of their workforce and resources. In the future, the contractors wouldn't be able to finish the job in the allotted time. The second reason is when inexperienced engineers estimate a project's timeline. The lack of funding at the appropriate time is also the reason why a project cannot be completed on schedule.

√ *Solution to avoid the above factor*

To evaluate a realistic project timeline, a well-experienced engineer should interact with the project team so that they can estimate the project duration by taking into account all potential site conditions learned from past projects. Another crucial factor to consider is the capacity of your team. Ask them about their present capacity and what jobs they will be able to take on, since their workloads may impact the time required to accomplish your project. To complete the project within the estimated time, the management should believe in teamwork and motivate them.

Factor-8: Unforeseen ground condition

√ *Root causes of the factor*

In most of the projects, clients/builders do not conduct soil investigations and even if they do, the numbers of bore logs drilled are insufficient resulting in encountering hard rock, filled in soil, poor soil, ground water table during construction. Later, to resolve this issue, the structure has to be redesigned and thereby causing the increase in quantities of earthwork, rock cutting etc., sometimes necessitating deep foundations and pile foundations etc.

√ *Solution to avoid the above factor*

Soil investigation has to be conducted for the entire proposed project layout and a sufficient number of bore logs as per standards shall be proposed/drilled to obtain a more realistic underground condition. In addition, while preparing the initial budget; 10-15% provision shall be made in the sub-structure cost to account for these issues.

Factor-9: Inaccurate quantity take-off

√ *Root causes of the factor*

Clients rush for budget at the beginning of the project before preparation and finalization of the plans, design, and specification. Due to the client's pressure, engineers typically prepare BOQs based on thumb rules or based on previously completed projects, which do not actually match the real quantities. Further, this duty is assigned to inexperienced engineers, who make mistakes and then the BOQ is finalized without proper checking and expert reviews.

√ *Solution to avoid the above factor*

Clients must allow reasonable time for the preparation of the BOQ, only after the finalization of the drawings and specifications. The duty of the preparation of the BOQ must be assigned to highly experienced engineers. The BOQ, so prepared, shall be reviewed so that the errors or items left out in the BOQ can be corrected/included before finalizing the same for tendering etc.

Factor-10: Delay in progressive payment by owner

√ *Root causes of the factor*

Many times the owners do not budget the project properly and do not have proper cash flow, hence

they are unable to pay on time regularly, which delays the project.

√ *Solution to avoid the above factor*

Owners shall ensure that before the onset of the project and the scheduled completion time, the project shall be accurately budgeted with 10-15% extra funds so that the project shall not suffer for want of funds.

8. Conclusions

On the basis of this study, the following conclusions have been drawn:

1) The opinions of respondents all over India were analyzed using the RII technique and the results revealed that the top ten critical factors influencing cost overruns in high-rise building construction are "Frequent change orders during construction by owner", "Delay in construction", "Escalation of material price", "Market inflation" "Rework", "Frequent changes in design", "Inaccurate evaluation of projects timeline", "Unforeseen ground condition", "Inaccurate quantity take-off", and "Delay in progressive payment by owner".

2) According to the results of Spearman's rank correlation test, there is a very significant relationship between the rankings of factors provided by the owner, the consultant, and the contractor. The degree of relationship between owners and contractors is the highest (about 71 percent). The degree of relationship between owners and consultants is the highest (about 72 percent), and the degree of relationship between contractors and consultants is the lowest (about 63 percent).

3) In order to uncover the core components of cost overrun factors, a factor analysis was carried out. After doing an analysis of the data, the following sixteen core components were extracted: "Site-specific issues", "Owner's financial capability", "Management related", "Incompetence", "Lack of experience", "Owner involvement", "Project related", "Contractor control", "Estimation related", "Equipment related", "Lack of constraint", "Labour related", "Contractor's financial control", "Other factors", "Market related", and "Productivity". This is crucial, especially if further research is to be performed on the components that have been extracted.

4) The suggestions for the top 10 critical factors have been collected from SMEs (subject matter experts) with a construction background and more than 25 years of experience. The suggestions collected from SMEs could be valuable for planning a new construction project.

5) The findings of this study, together with the advice of construction industry experts, might lead to better cost management and reduced likelihood of future cost overruns.

9. Future research

In this part, we suggest areas of future study where we believe more information would increase the quality of the research presented here. The numerous obstacles and problems found during the course of this research have produced a number of suggestions for future work aimed at expanding the bounds of knowledge. The following recommendations are provided:

Construction managers and construction firm holders can use this data to control costs,save time, and improve work efficiency. This study can be further extended to explore the outcome of the given recommendations. While this study focused on the causes of cost overruns in high-rise building construction, further research can look into other types of construction projects as well.

Conflict of Interest

There is no conflict of interest.

References

[1] Towey, D., 2013. Cost management of construction projects. Wiley-Blackwell: Hoboken.

[2] Chadee, A.A., Chadee, X.T., Ray, I., et al., 2021. When parallel schools of thought fail to converge: The case of cost overruns in project management. Buildings. 11(8), 321.

[3] Doloi, H., 2013. Cost overruns and failure in

project management: Understanding the roles of key stakeholders in construction projects. Journal of Construction Engineering and Management. 139(3), 267-279.

[4] Mahmood, H., 2020. Construction cost overruns in Afghanistan: A review of significant factors [PhD thesis]. Istanbul: Bogazici University.

[5] Chadee, A.A., Martin, H.H., Mwasha, A., et al., 2022. Rationalizing critical cost overrun factors on public sector housing programmes. Emerging Science Journal. 6(3), 647-666.

[6] Ali, A.S., Kamaruzzaman, S.N., 2010. Cost performance for building construction projects in Klang Valley. Journal of Building performance. 1(1).

[7] Infra Projects Cost Escalated by Rs 1.23 Lakh Crore in 11th Plan [Internet] [cited 2022 Feb 24]. Available from: https://economictimes.indiatimes.com/news/economy/finance/infra-projects-cost-escalated-by-rs-1-23-lakh-crore-in-11th-plan/articleshow/18868951.cms

[8] International Building Code (IBC) (2000) [Internet] [cited 2022 Feb 25]. Available from: https://ia800303.us.archive.org/29/items/gov.law.icc.ibc.2000/icc.ibc.2000.pdf

[9] Share of High-rise Launches at All-time High of 52% in 2019: Report [Internet]. Available from: https://economictimes.indiatimes.com/industry/services/property-/-cstruction/share-of-high-rise-launches-at-all-time-high-of-52-in-2019-report/articleshow/73371629.cms?from=mdr

[10] Construction Industry of India [Internet] [cited 2022 Feb 25]. Available from: https://en.wikipedia.org/wiki/Construction_industry_of_India

[11] Moon, H., Williams, T.P., Lee, H.S., et al., 2020. Predicting project cost overrun levels in bidding stage using ensemble learning. Journal of Asian Architecture and Building Engineering. 19(6), 586-599.

[12] Khodeir, L.M., El Ghandour, A., 2019. Examining the role of value management in controlling cost overrun [application on residential construction projects in Egypt]. Ain Shams Engineering Journal. 10(3), 471-479.

[13] Flyvbjerg, B., Ansar, A., Budzier, A., et al., 2018. Five things you should know about cost overrun. Transportation Research Part A: Policy and Practice. 118, 174-190.

[14] Bucciol, A., Chillemi, O., Palazzi, G., 2013. Cost overrun and auction format in small size public works. European Journal of Political Economy. 30, 35-42.

[15] Ammar, T., Abdel-Monem, M., El-Dash, K., 2022. Risk factors causing cost overruns in road networks. Ain Shams Engineering Journal. 13(5), 101720.

[16] Shehu, Z., Endut, I.R., Akintoye, A., et al., 2014. Cost overrun in the Malaysian construction industry projects: A deeper insight. International journal of Project Management. 32(8), 1471-1480.

[17] Enshassi, A., Mohamed, S., Abushaban, S., 2009. Factors affecting the performance of construction projects in the Gaza strip. Journal of Civil engineering and Management. 15(3), 269-280.

[18] Kamaruddeen, A.M., Sung, C.F., Wahi, W., 2020. A study on factors causing cost overrun of construction projects in Sarawak, Malaysia. Civil Engineering and Architecture. 8(3), 191-199.

[19] Kavuma, A., Ock, J., Jang, H., 2019. Factors influencing time and cost overruns on freeform construction projects. KSCE Journal of Civil Engineering. 23, 1442-1450.

[20] Oladapo, A.A., 2007. A quantitative assessment of the cost and time impact of variation orders on construction projects. Journal of Engineering, Design and Technology. 5(1), 35-48.

[21] Chan, C.T., 2012. The principal factors affecting construction project overhead expenses: An exploratory factor analysis approach. Construction Management and Economics. 30(10), 903-914.

[22] Goh, K.C., Yap, A.B.K., Seow, T.W., et al., 2015. Strategies in dealing with cost overrun issues: Perspective of construction stakeholders. InCIEC 2014: Proceedings of the International Civil and Infrastructure Engineering Conference

2014. Springer: Singapore. pp. 189-198.

[23] Iyer, K.C., Jha, K.N., 2005. Factors affecting cost performance: Evidence from Indian construction projects. International Journal of Project Management. 23(4), 283-295.

[24] Le-Hoai, L., Lee, Y.D., Lee, J.Y., 2008. Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. KSCE Journal of Civil Engineering. 12, 367-377.

[25] Musarat, M.A., Alaloul, W.S., Liew, M.S., 2021. Impact of inflation rate on construction projects budget: A review. Ain Shams Engineering Journal. 12(1), 407-414.

[26] Mansfield, N.R., Ugwu, O.O., Doran, T., 1994. Causes of delay and cost overruns in Nigerian construction projects. International Journal of Project Management. 12(4), 254-260.

[27] Aziz, R.F., 2013. Factors causing cost variation for constructing wastewater projects in Egypt. Alexandria Engineering Journal. 52(1), 51-66.

[28] Asiedu, R.O., Adaku, E., 2020. Cost overruns of public sector construction projects: A developing country perspective. International Journal of Managing Projects in Business. 13(1), 66-84.

[29] Asiedu, R.O., Frempong, N.K., Alfen, H.W., 2017. Predicting likelihood of cost overrun in educational projects. Engineering, Construction and Architectural Management. 24(1), 21-39.

[30] Famiyeh, S., Amoatey, C.T., Adaku, E., et al., 2017. Major causes of construction time and cost overruns: A case of selected educational sector projects in Ghana. Journal of Engineering, Design and Technology. 15(2), 181-198.

[31] Sharma, S., Goyal, P.K., 2019. Fuzzy assessment of the risk factors causing cost overrun in construction industry. Evolutionary Intelligence. 15, 2269-2281.

[32] Durdyev, S., 2021. Review of construction journals on causes of project cost overruns. Engineering, Construction and Architectural Management. 28(4), 1241-1260.

[33] Durdyev, S., Omarov, M., Ismail, S., et al., 2017. Significant contributors to cost overruns in construction projects of Cambodia. Cogent Engineering. 4(1), 1383638.

[34] Narayanan, S., Kure, A.M., Palaniappan, S., 2019. Study on time and cost overruns in mega infrastructure projects in India. Journal of The Institution of Engineers (India): Series A. 100, 139-145.

[35] Kim, S.Y., Tuan, K.N., Lee, J.D., et al., 2018. Cost overrun factor analysis for hospital projects in Vietnam. KSCE Journal of Civil Engineering. 22, 1-11.

[36] Wanjari, S.P., Dobariya, G., 2016. Identifying factors causing cost overrun of the construction projects in India. Sādhanā. 41, 679-693.

[37] Frimpong, Y., Oluwoye, J., Crawford, L., 2003. Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study. International Journal of Project Management. 21(5), 321-326.

[38] Polit, D.F., Hungler, B.P., 1985. Essentials of nursing research: Methods and applications. Lippincott Williams & Wilkins: Philadelphia.