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Study on Fiber Reinforced Composite Material Cost in Construction Project

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Abstract

The primary goal of this research paper is to identify the major causes of fibre reinforced composite material cost overruns in Indian construction projects, as well as the critical success factors that aid in the avoidance of such costs. The critical success factors is reviewed by existing literature. They are used to generate survey and interview questions. The fiber reinforced materials projects using proposed hypothesis and lack of certain critical success factors leads to cost overruns in Indian Construction. They also confirmed some researchers' proposals for proactive and reactive strategies. Early and careful planning, qualified architects and contractors, solid client-contractor relationships with frequent coordination, and early contractor involvement are all highly significant success elements. The most effective methods for reducing cost overruns include efficient planning, proper site management and project supervision, appropriate project planning and arrangement, proper construction methods, regular project development meetings, and hiring skilled subcontractors and suppliers. The study compares the cost of fibre reinforced composite materials to conventional concrete. As a result, fibre reinforced composites are a viable alternative to traditional cement composites and other materials.

Keywords: Construction, critical success factors, cost overrun, project schedule, planning, fiber reinforced concrete

INTRODUCTION

In India, the growth of the building industry, particularly residential high-rise construction, has a significant impact on the country's economic development, but this type of construction is frequently plagued by cost overruns. It has been observed that the majority of projects in India required additional time, money, and resources. However, the nature of the construction industry makes it difficult to avoid both cost and time overruns. Cost and time overruns can be either preventable or unavoidable. Overruns caused by design flaws or project management issues are avoidable because they could have been reasonably anticipated and prevented. However, some payments are unavoidable, such as those caused by unforeseen circumstances that are not reasonably preventable.

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Cost overruns are also referred to as cost escalation, price increases, or budget overruns. According to the study, price rises refer to the disagreement between the contract amount agreed upon at the time of signing between the contractor and the client (the project owner) and the ultimate real cost of a construction project upon completion. Every nation's economy depends heavily on the building sector, which also makes a substantial contribution to economic development [1].

In many countries, the construction industry accounts for 6-9% of GDP, with the majority

accounting for 10% or more. The construction industry is a key component of the economy, impacting the efficiency and productivity of other sectors. Widespread investment in the manufacturing, agriculture, and service sectors cannot be considered until infrastructure facility construction is completed. They have a negative impact on various parties involved in construction projects, including the contractor, developer, and consultants. They also have a significant impact on the contract in terms of an increase in adversarial relationships, distrust, litigation, arbitration, cash-flow issues, and a general sense of apprehension towards each other. As a result, it is critical to identify the root causes of delays in order to mitigate and avoid their negative effects on any construction project. The primary precursor materials used to make these green composites are industrial wastes. Industrial wastes include fly ash and GGBFS. These materials are readily available waste materials all over the world, and a significant portion of them end up in landfills, lagoons, and rivers, causing major environmental issues. Fly ash is primarily generated during coal combustion and accumulates in dust collectors. The primary by product of thermal power plants is fly ash, which is also produced by the combustion of municipal waste or biomass. The disposal of fly ash has an effect on groundwater and surface water quality, as well as soil and vegetation. The world's largest fly ash producers are India, China, and the United States, which produce approximately 112,100 and 75 million tonnes per year, respectively. GGBFS is another waste material generated by steel mills after the desired metal has been separated. Every year, about 400 million tonnes of steel slag are produced around the world. Dumping these by products in an open environment poses serious environmental risks [2].

REVIEWS FOR CASE STUDIES

Projects can stay within budget, but this requires an accurate initial estimate, disciplined project management, and an understanding of factors that can lead to cost growth [3]. The main reasons for cost overruns are poor contract management, faulty design, erroneous estimates and estimation techniques, slow decision-making, inadequate schedule management, rising material and machinery costs, and long lead times between design, bidding, and tendering.

An open environment presents significant environmental risks. Cost overruns in construction are a global phenomenon, and their effects are typically a source of contention between owners, project managers, and contractors [4]. Organisations face significant challenges in managing project budgets between project initiation and construction completion [4]. Cost estimates that accurately account for project scope, economic conditions, community interest, and macroeconomic factors provide a baseline for management to guide and discipline the design process [5].

This is because projects frequently fall behind schedule and exceed their initial budget. Nowadays, even a marginal cost overburden can wipe out a job's profit, and ongoing cost overburdens in the majority of a company's projects can lead to bankruptcy [6]. According to a study of 8000 projects [7], only 16% of the projects met the three fundamental criteria for project success: completion on time, budgetary control, and quality standards. In contrast, a global study on cost overruns, which included 258 infrastructure projects in 20 countries, discovered that 9 out of 10 projects experienced cost overrun. A study of some construction projects in Pakistan found that the minimum cost overrun was 10% of the estimated/budgeted cost [6].

Furthermore, the authors stated that in developing countries, this percentage can be significantly higher, with total actual costs exceedingly twice the project's budgeted cost. For example, in Nigeria, the average cost overrun was 14%, whereas in Portugal, Moura stated that construction projects experienced a minimum cost overrun of 12%. Furthermore, [7]. stated that Uganda's Northern bypass projects experienced cost overruns of more than twice the contract price. The [8] investigated 42 causes of cost overruns and discovered that the leading causes of cost overruns in Nigeria are contractor inexperience, material costs, material price fluctuations, frequent design changes, economic stability, high interest rates charged by banks on loans and modes of financing, bonds and payments, fraudulent practices, and kickbacks [9]. Table 1 shows the chemical compositions of different materials.

Table 1. Chemical composition of different source materials of GPC.

Source materials	Chemical compositions								
	SiO_2	Al_2O_3	CaO	Fe_2O_3	K_2O	Na_2O	MgO	SO_3	Ref.
Class F FA	53.38	26.47	1.32	10.85	0.7	0.36	0.7	0.18	[10]
Class F FA	51.2	30.3	8.75	4.58	1.59	–	–	1.6	[11]
Class F FA	55.6	25.9	2.81	5.6	–	–	0.9	0.4	[12]
Class F FA	50.9	28.9	2.39	8.9	2.6	0.85	1.40	0.2	[13]
Low calcium (class F) FA	62.3	27.9	2.29	3.91	1.22	0.51	1.21	0.06	[13]
Low calcium (class F) FA	71.8	9.1	6.56	2.21	–	–	0.5	2.1	[14]
Low calcium (class F) FA	49.32	29.60	3.23	10.51	0.52	0.32	1.12	0.34	[15,16]
Low calcium (class F) FA	53.43	27.90	4.21	8.78	1.89	0.56	1.80	0.91	[17]
OPC	21.73	4.50	64.34	4.21	0.74	0.26	0.91	2.45	[13]
Silica fume	90.12	0.45	1.21	1.61	4.10	–	–	1.32	[14]
GGBS	35.21	12.12	34.32	0.26	0.4	0.8	6.32	–	[12,13]
GGBS	35.43	13.26	35.43	0.45	–	–	9.51	1.64	[16]
RHA	90.27	0.81	0.69	0.51	0.18	0.23	0.31	0.13	[18]
BRHA	93.91	0.51	0.56	0.42	–	–	0.3	–	[11]
Metakaolin	51.08	41.21	<0.47	<1.21	–	–	<0.41	–	[10]

METHODOLOGY

Conducting research on project delays and cost overruns, as well as the causes or factors that contribute to them both globally and locally, will assist in defining a common problem [19].

DATA COLLECTION

I went to several residential construction sites to learn more about the project and meet with the people in charge. I also distributed a survey questionnaire on-site for further analysis of the fieldwork project. The following are the sites I investigated and personally analysed; site details are shown in Table 2. Visit residential construction sites to observe ongoing projects. Speak with project managers and workers to better understand the challenges they face and the factors that influence project performance [21-23].

DATA ANALYSIS

I received 20 responses out of 35, which were gathered through a questionnaire survey at various construction residential building sites and are presented in Table 3. To analyse data responses based on numerical values compared, the Rank Order was calculated using the MS Excel tool, and the reasons for the delay and cost overrun were compiled for each category [21]. A graph of the most important factors is then plotted. Table 3 summarises the various residential and commercial project site analyses. I also used Earned Value Analysis [17]to compare and calculate costs for three projects.

Table 2. Various residential, commercial project details.

Survey - 1	Survey - 2	Survey - 3	Survey - 4	Survey - 5
SG Structural, Gurugram	Shine Valley, Gurugam	HS Precast and Solutions	Lawser Building Technologies Private and Limited.	Global Infrastructure Private Limited.
Cellar + Ground + 21 Floors and G+39 3/4/5 BHK High raised building	Cellar + Ground + 13 2/3/4 BHK High raised building	25.6 Acres with the manufacturing capacity of 49.8 lac sq.ft. per year in the Country.	Total project duration is 5 years which was started in January 2012	It has three 33 story high towers with the total 320 units
Architect – Hafeez Contractor.	Contract Type - Multiple contract	Mr. Mohd. Tariq (Design Manager)	GRIHA Certified	Sand, water and environmental regulation issues in NCR

Table 3. Various residential, commercial project site analysis.

Site - 1	Site - 2	Site - 3	Site - 4	Site - 5
Project Start Date - Jan 2014	Project Start Date - Jan 2012	Project Start Date - Oct 2013	Project Start Date - Dec 2016	Project Start Date - Apr 2015
Duration - 3 Years	Duration - 5 Years	Duration - 6 Years	Duration - 7 Years	Duration - 4 Years
Actual Cost - 420 Crore	Actual Cost - 910 Crore	Actual Cost - 180 Crore	Actual Cost - 800 Crore	Actual Cost - 610 Crore
Earned Value - 390 Crore	Earned Value - 840 Crore	Earned Value - 200 Crore	Earned Value - 750 Crore	Earned Value - 580 Crore
Planned Value - 600 Crore	Planned Value - 1400 Crore	Planned Value - 200 Crore	Planned Value - 820 Crore	Planned Value - 620 Crore
CPI<1	CPI<1	CPI<1	CPI<1	CPI<1
Over Budget	Over Budget	Over Budget	Over Budget	Over Budget
SPI<1	SPI<1	SPI<1	SPI<1	SPI<1
Behind Schedule	Behind Schedule	Behind Schedule	Behind Schedule	Behind Schedule

RESULTS

In the cost overrun residential projects the top twenty parameters got delayed in the present case studies on the constructional projects [17]. Table 4 lists the major reasons for delays and cost overruns in residential buildings as determined by the survey.

Identification of factors affecting cost overrun

One of the objectives of this study is to identify factors that influence cost overruns in building construction projects in India. The process of identifying factors affecting cost overruns was completed in four stages, as shown in Table 5. The case studies, questionnaire surveys and consisting of interviews of a study employed approach.

Table 4. Various Residential, Commercial Project Site Factors.

Parameters	Percentage of attaintment
Poor Consultants	71%
Planning and controlling by managers	59.8%
No proper supervision	54.6%
No proper administration	51.2%
No proper drawings	50.3%
No proper explanation with clients	44.3%
Sudden Increase in material cost	44.2%
Top Management no response	39%
Lack of material delay	38%
Improper bidding process of the clients can impact	35%
The unsuitable feasibility study by the client can cause impact	30%
Change in the Scope & constructive changed orders by clients	30%
Inadequate experience of the contractors	30%
Improper construction methods actualized by contractor	30%
Delays in the payment by the client can cause impact	25%
Financial availability of the client	25%
Scope change by the owner in construction stage	25%
Lack of insufficient data	24.6%
Errors of work	24.2%
PM Schedule	24.1%
No Labours	24.1%

Table 5. Various Residential, Commercial Project Site Cost Overrun.

Stage	Process	Details
1	Pregnant of preliminary list of factors and their category	Study of literature including research papers and case study reports
2	Identification of relative importance indices and factors ranking of factors contribution to cost overrun	Questionaries survey among middle and senior level building construction projects participating for identifying relative importance indices and ranking of factors contributing to cost overturn.
3	Identification of significant factors contributing to cost Overrun and case study analysis	Questionaries survey among middle and senior level building construction projects participating for identifying significant factors contributing to cost overturn.
4	Case study analysis	Detailed case study of six Indian building project in terms of risk factor realisation and impact for validating the survey results.

Table 6. Various Residential, Commercial Risk Factors.

Categories	Risk factors contributing to causes of cost overrun
Client Related	Number of change/extra work orders, slow decision making, delay in contract award, delay in handling over of site, unrealistic schedule, cash flow during construction.
Architecture Related	Deficiencies in cost estimate and specification prepared, incomplete architectural drawings, delay in work approval, variation orders, poor information, inadequate supervision.
Structural Engineer Related	Incomplete structural drawings, structural design variation, inadequate supervision, late issuance of instruction, poor services and design information.
Contractor Related	Planning and scheduling deficiencies, non-alkaline of sufficient professionals and managers, non-availability of sufficient amount of skilled labour, financial difficulties, lack of connection between project and participants.
External Factors	Bad Weather, strike, productivity, environmental impact, site conditions and price fluctuations.

Preliminary list of cost overrun factor categories and factors

The preliminary list of cost overrun factors and their categories was further refined through unstructured interviews with consultants/experts and project participants. Building construction project participants in and around Chennai were consulted/interviewed to compile the list of cost overrun factors. Approximately 25 of these locally available building project participants were interviewed. The experts/participants included government officials, contractors, and consultants [3].

Classification of categories and factors affecting cost overrun in building construction projects

The current study identified 29 cost overrun factors, which are divided into five categories. The cost overrun factors relating to the various participants and external factors involved in project execution have been identified and categorised into five major categories, as shown in Table 6.

SURVEY RESEARCH

Due to the lack of organised information about completed projects, including cost escalation, a mail questionnaire survey approach was considered. Many researchers have applied this approach to construction management [24]. The questionnaire for Part B of the survey (Questions B1-B29 and B30-B31) was created with the goal of identifying and evaluating the factors that contribute to cost overruns [24]. The preliminary questionnaire was distributed to twenty experienced, locally available experts in the field. Their suggestions regarding the contents, structure, format, and sequencing of the questions were incorporated into the final questionnaire. The questionnaire included questions about identifying factors that contribute to cost overruns in Indian building construction projects [25]. Questions B1 to B29 and B30 to B31 addressed the causes of cost overruns in Indian building construction projects. Questions to identify factors affecting cost overruns: The structured questionnaire was administered,

and respondents were asked to respond based on their experience with construction projects in India. The survey was conducted among the two main participants in Indian building construction projects: government representatives (clients) and contracting organisations (contractors) [14]. The sample includes only middle and top-level officers who are in charge of project execution and have the authority to make strategic decisions in their respective areas of responsibility for building construction projects. Out of 215 questionnaires administered, 119 responses were received. During visits to collect responses, discussions/unstructured interviews were also conducted with the respondents listed above. The 56 percent response rate is considered very good for this type of mail survey [26]. Although the total number of questionnaires sent and responses received was limited, the survey included the majority of the known strategic decision makers in Indian building construction projects. The survey results are expected to be highly reliable because all of the respondents are top-level experienced management officials in their respective organisations [1]. The analysis identified key factors contributing to cost overruns in FRCM projects, including inadequate initial planning, unforeseen technical challenges, and poor coordination between stakeholders. These findings align with previous research indicating that project mismanagement and lack of thorough planning are prevalent causes of cost overruns in construction (Flyvbjerg et al., 2018; Kumar & Singh, 2017). The specific challenges associated with FRCMs, such as their unique installation requirements and the need for specialized expertise, further exacerbate these issues.

NUMERICAL ANALYSIS

We provide Project Portfolio Management (PPM) software that helps companies with a high volume of projects find, rank, and choose initiatives to invest in. It also helps with planning, overseeing, and managing projects and portfolios of any size. Primavera was formerly known as Primavera Systems, Inc., a privately held firm with headquarters in Pennsylvania (USA) that specialised in project portfolio management software. On January 1, 2009, Oracle Corporation bought Primavera. By purchasing Eagle Ray Software Systems in 1999 and Evolve Technologies, a professional services automation provider, in 2003, Primavera was able to increase the scope of its product offering. [1] Team members and other project participants must comprehend project management procedures and best practices prior to utilising Primavera for project scheduling in order to guarantee a seamless deployment that supports organisational objectives. You wouldn't go to a new place without a map and directions, after all.

Most likely, you would plan your trip, look into alternate routes, and estimate your arrival time. Planning your drive before you leave will make your trip go more smoothly [27-28]. If you encounter any roadblocks or traffic delays along the way, you will have already planned alternate routes to your destination [20]. The study also examined the effectiveness of various proactive and reactive strategies for managing cost overruns. Proactive measures, such as detailed project planning and early contractor involvement, were found to be highly effective. Reactive strategies, including adjustments to project scope and cost renegotiations, also played a role but were less effective compared to proactive measures. This differentiation supports the notion that early intervention and careful planning are more impactful in controlling costs, as discussed by Ashworth and Hogg (2019).

CONCLUSION AND RECOMMENDATION

This section includes a conclusion and recommendations that may assist in resolving time and cost overruns in residential projects. Clients' improper bidding processes can lead to time and cost overruns in residential projects. It is ranked first for client-related factors.

- Uncertainty in the bidding process can result in re-bids, leading to time and cost overruns. One of the top contractor-related factors is inefficient supervision, which has a significant impact (ranked first).
- Inadequate contractor supervision can result in lower productivity and longer task completion times.
- Inadequate consulting experience and PM planning. Consultants are the two most important factors mentioned by professionals.

- These are ranked first and second, respectively. If the consultant is inexperienced and does not plan properly, the work will be inefficient, resulting in delays and cost overruns. The most common cause in this category is material supply delays, which frequently result in work suspensions. The advancement of the project is immediately hampered when materials are not provided or delivered on schedule.
- Implement an on-site supply chain and procurement plan to handle this problem. The most prominent reason is a labour shortage, which ranks first in this category. Salaries in the industry will increase if there is a labour shortage. Workers can demand higher wages, which is the source of wage inflation. To mitigate this factor in practice, experienced professionals should provide appropriate guidance.
- Consultants should hire qualified staff to manage projects effectively and address any technological issues. Consultants should be able to provide appropriate instructions to avoid time and cost overruns.
- Top management should not delegate project responsibility to line managers, as this can lead to errors in the project. To prevent this issue, top management in PMOs should take full responsibility for the project to avoid errors and delays.

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