Analyzing Factors affecting Cost and Time overruns in Indian Public Sector Projects at Portfolio Level

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***Abstract*—The construction industry plays a crucial role in the economic development of developing and underdeveloped countries. Infrastructure quality is vital for a country's progress, and public sector projects are responsible for maintaining and improving it. However, many construction projects face delays, exceeding time, and cost estimates. Construction delays are a global issue, leading to cost overruns. Prioritizing cost efficiency at the portfolio level allows authorities to manage resources effectively while maintaining quality and completing projects on time. Research is needed to explore ways public sector entities can reduce project costs and ensure timely completion. The Research topic is inclined towards Indian Public sector projects. The targeted respondent for the survey questionnaire is industry professionals from the construction industry. The data collected through survey questionnaire is analysed through IBM SPSS & AMOS software. The Google Form Questionnaire contains 16 Main Factors affecting cost and time overruns in Indian public sector project at portfolio level. In this survey we received 296 responses, and the complete data was used for analysis. For Data analysis, Different methods of tests are performed in the research with the help of IBM SPSS & AMOS software like Cronbach's Alpha for reliability, KMO for Sampling adequacy, Kendall's W test for ranking of the key main factors, exploratory factor Analysis and confirmatory factor analysis. The Key findings from the study identification of the top 5 factors affecting cost and time overruns in Indian public sector at portfolio level. Top 5 factors affecting are C2 (Consultant Factors) Poor communication and coordination with the contractor and other project stakeholders affect both cost and time overruns, CL2 (Client Factors) Slow decision-making process affect time overruns, CL3 (Client Factors) Change in scope can affect both cost and time overruns, EX2 (External Factors) Any Political/Nonpolitical/Force majeure events can affect both cost and time overruns and EX3 (External Factors) Inclement weather conditions can affect time overruns. Recommendations were additionally given considering the top 5 factors, based on the construction groups and overall, in general for Indian public sector projects at the portfolio level, followed by the limitations and future scope of the work.**

***Index Terms*—Cost Overruns; Time Overruns; Public Sector Projects; Project Portfolio; Indian Construction industry**

I. INTRODUCTION

For decades, the construction industry has been characterized by costs exceeding budgetary limits and completion times reaching further than what was set out initially. This has been particularly noticeable for large public construction projects where cost overruns and time delays have long been regarded as common occurrences (Adam, et al., 2015). Despite the widespread growth, the construction industry encounters challenges such as cost overruns, disputes, and delays. However, developing countries face distinct problems due to global market conditions, limited resources, lack of skilled team members, budget constraints, and intense competition in the construction business (Ingle, et al., 2021). The construction industry operates on a project-based model, requiring collaboration among various stakeholders to achieve project completion. Each project is distinct in terms of its scale, complexity, functionality, scope, and other factors. Construction Cost overruns and schedule delays are common problems; they are not restricted to any public or private projects. (Asiedu & Adaku, 2020) states that cost overruns of construction projects have been a key concern among all the stakeholders of projects for many decades now. The Challenges of cost overruns

and time delays is clearly a global phenomenon and although there are minor differences depending upon the geographical location (Adam, et al., 2017). As a India is a developing country, Currently public sector projects in India are in demand and crucial for the development and maintenance of public infrastructure like roads, bridges, dams, railways, tunnels, and so on since most developing countries spend relatively significant portions of their GDPs on construction projects in the construction industry, it is important that the performance of projects in the industry is paid attention to ensure efficient use of the taxpayer's money (Asiedu & Adaku, 2020). In developing country like India, where there are fiscal challenges, this call becomes even more urgent. One such performance measure, especially for public sector projects in the industry, is cost. This is because every client or construction project sponsor would like to have the construction project completed within a specified or agreed upon budget and on time (Asiedu & Adaku, 2020). Cost is arguably one of the most fundamental criteria for measuring the success of any project (Shehu, et al., 2014). According to (Adam, et al., 2017) in particular, with regards to large scale public projects. The existing tendency is to regard cost overruns and delays as types of risks. Projects are basically temporary structures in which individuals with diverse skills collaborate to accomplish a complex objective (Mahura & Birollo, 2021). These temporary and interdisciplinary structures are considered as entities that come together to create what we recognize as project-based organizations (PBOs) (Mahura & Birollo, 2021). PBOs strive to guarantee that the knowledge produced in a specific project can be shared, applied, and integrated into other interconnected projects to cultivate project capabilities (Mahura & Birollo, 2021). PMOs were created to help project-based organizations effectively manage and coordinate their project portfolios (Bredillet, et al., 2018). Our conceptual process model consists of three steps: conceptualizing portfolio management (PFM) as a collection of routines that form an organizational capability, conceptualizing the PMO as an organizational meta-artifact designed to address PFM-related problems, and mapping the relationships between the PMO, PFM, and the broader organization onto a process model of routine (re-)creation (Bredillet, et al., 2018). Large Public sector Projects often referred to as mega projects in terms of expensiveness, physical nature and their impact on society leading to increased public attention, due to the magnitude and frequency of these overruns, they have come to pose a significant financial risk to both clients and contractors, in addition to the impact exerted on the sustainability of the project (Adam, et al., 2015). Execution of mega infrastructure projects faces numerous challenges and results in significant time and cost overruns in India. Mainly Infrastructure projects are classified into two types of, namely major infrastructure projects and mega infrastructure projects. According to (Narayanan, et al., 2019) Projects with planned/budgeted cost more than 1000 crores are named as mega infrastructure projects. Projects with budgeted cost more than 150 crores but less than 1000 crores are considered as major infrastructure projects. Hence, achieving cost efficiency and less schedule delays at the public sector project at portfolio level allows public authorities to optimize resources and deliver projects within budget while ensuring quality and functionality. According to (Doloi , et al., 2012) the Indian construction sector has acted as an engine of growth for the Indian economy for over the past five-decades and becoming a basic input for the socio-economic development of the country. While the importance of Indian construction sector over the past five years has grown significantly, lack of sophistication across the construction supply chain is one of the key issues in the industry (Doloi , et al., 2012). Projects are reportedly failing across all the key performance measures including cost, time, and quality performances. (Clegg, et al., 2018) The reality of cost strategic initiatives at the project portfolio level uncovers linkages between good practices, organizational learning, and change management. To Sum up, the paper should be focusing on investigating the factors affecting cost overruns and time overruns Indian construction industry at project portfolio level. A theoretical study i.e., Literature review is done on the public sector and how they conduct an initiative to lower the overall cost of their projects with timely completion (Beste Teresa, Klakegg Ole Jonny, 2022). Followed by next research context, then data collection, and data analysis through IBM SPSS software and followed by the findings. The Paper ends by discussing the objectives of the work and what is achieved, a set of recommendations and presenting the limitations, future scope of work.

1.1 Research Gap

The current research in various literatures basically focuses on cost and time overruns on individual projects, neglecting the broader portfolio perspective. While there has been broad research on cost-influencing factors and time overruns in public sector projects, there's a notable gap within the existing literature concerning the holistic relation of factors impacting cost and time at the portfolio level in Indian public sector projects. This research gap is critical, as it fails to provide a comprehensive understanding and has no proper correlations between cost and time overruns in public sector projects in India at portfolio level. Hence, preventing the development of successful mitigation measures, a set of recommendations, and approach strategies at a portfolio level.

1.2 Research Aim

To identify and assess multifaceted factors affecting cost and time overruns and to propose set of recommendations to avoid cost and time overruns in Indian Public Sector Project at Portfolio Level.

1.3 Research Objectives

- To identify and categorize the main key factors contributing to cost overruns in Indian public sector project at Portfolio.
- To identify and categorize the main key factors contributing to time overruns in Indian public sector project at Portfolio.
- To develop questionnaire survey, collect Data from Industry professionals and to analyze the relationship between cost and time overruns and several variables (Main Key Factors) and rank the main key factors.
- To Propose a set of recommendations to avert cost overruns and time overrun

II. LITERATURE REVIEW

2.1 Causes of Cost overruns

In Developing Countries, Corruption carries a significant impact on Actual costs and accounts for 10-30 % of the value of a single construction contract (Adam, et al., 2017). According to (Adam, et al., 2017) root causes for cost overruns are identified as inefficient communication between client and contractors, Poor financial planning, Price increases, Poor Site management, Poor monitoring and control, Client initiated change orders, Rework, Project complexity, Project duration, Optimism bias, and Unforeseen ground conditions. Similarly, (Cheng, 2014) advises that price fluctuations are one of the factors that should be monitored regularly by the contractor and reflected to the client. (Cheng, 2014) studies show that clearly defined scope of project in the contract and cost control are the major determinants for cost overrun. Also, Environmental & Circumstantial influence, Scope of Contract, Project Risks, Management and Techniques are the key categories with high influence on project cost (Cheng, 2014). As per findings from (Asiedu & Adaku, 2020) show that there are primarily four major causes of most public sector construction projects cost overruns and that are (1) Poor contract planning and supervision. (2) Change Orders. (3) Weak institutional and economic environment of project. (4) Lack of effective coordination among the contracting parties. (Steininger, et al., 2021) investigated the causes for the cost overrun of the railway project Stuttgart21 and finds scope changes, geological conditions, high risk-taking propensity, extended implementation, price overshoot, conflict of interests and lack of citizens' participation are the major causes. Similarly for the Malaysian construction industry a sample of 359 recently completed construction projects data were analyzed in terms of project financial outturn based on: contract values; project sector; type of project; procurement route; nature of projects; and tendering method used. (Shehu, et al., 2014) Based on procurement and tendering methods suggests that design and build was associated with reduced cost overrun, whereas, selective tendering experienced 48% cost overrun followed by negotiated method (52%) then open method (60%). In terms of project size, small and large projects performed better than medium and exceptionally large projects (Shehu, et al., 2014). (Steininger, et al., 2021) detects that Underestimation of costs at the beginning of project planning and no improvements in the estimation process for over last 70-80 years affects the cost performance. On Contrary (Adam, et al., 2015) detects that both the construction technology and the techniques for estimating costs have improved with time, the observation that level of cost increases still persist may instead suggest that the root cause of the problem is not engineering nor accounting but rather

in the realm of politics. For (Steininger, et al., 2021) cost overruns are broadly divided into four factor (1) Technical which includes incomplete estimation, uncertainty over future events or errors in decision making processes. (2) Economical which includes neoclassical theory and rational choice theory. (3) Psychological includes planning fallacy, optimism bias and cautious attitudes. (4) Political includes theory of Machiavellianism and Ethical conduct. Furthermore, Geological conditions and unexpected underground obstacles leads to cost overruns of mostly public infrastructure project (Steininger, et al., 2021). Whereas, according to (Adam, et al., 2015) political explanations can be explained by Machiavellian theory (focuses on power and influence) or agency theory (focuses on motives based on self-interest). According to (Makovsˇek, et al., 2012) the fundamental issue of systematic cost overruns arises from the inefficient distribution of investment resources, which leads to a distortion in the cost-benefit analysis and the approval of potentially misguided investments as in economies that have undergone recent changes or market fluctuations, it is crucial to exercise due diligence when evaluating and interpreting cost performance. According to (Kaliba, et al., 2009) major causes of cost escalation in road projects in Zambia were Bad weather, Inflation, Schedule delays, scope changes, Environmental protection, and mitigation costs. For international projects (Ahsan & Gunawan, 2010) listed major causes of cost underrun were depreciation/devaluation of local currency, Lower than estimated price for procurement of goods, services, and contracts, Competitive international bidding, Less use of contingency funds, Project scope cut, Project design change, Local taxes and interest policy change. As per (Famiyeh , et al., 2017) Financial difficulty by client, Poor Contract Management, Inaccurate estimates, Slow permits by Govt. agencies, Material price changes, Bad weather are major reasons for cost overruns in educational sector projects in Ghana. Similarly, In Malaysian construction, according to (Shehu, et al., 2014) Slow permits govt. department, Improper construction method implemented by the contractor are major reasons for cost overruns. In UAE industry complex multi-stakeholder road projects, (Al Hosani, et al., 2020) found 10 key factors Delays in decisions making by the approval authorities, Change design, Incomplete design drawings and specifications at tendering stage, Changes in client requirements, Errors and omission in design, Scope and specification changes, Cashflow problem during construction, Contractor's financial difficulties, Construction cost underestimation affecting the cost of the project. Similarly, for the UAE Construction industry (Johnson & Babu, 2018) Design variation from client and consultant, Poor cost estimation of the project, Delay in client's decision-making process, Financial constraints of client, Inappropriate procurement method, Lack of risk management during the execution phase of the project, Poor initial planning, Lack of client's experience, Lack of flexibility in design, In efficient contractor performance Lack of understanding the contract conditions by the project participants were major factors causing cost overruns.

2.2 Causes of Time overruns

According to (Adam, et al., 2017) root causes for time delays are identified as inefficient communication between client and contractors, Delayed Payment to contractors/consultants, Poor Site management, Inadequate managerial skills, Poor monitoring and control, Slow decision making, Client initiated change orders, Inadequate design specs, Rework, Poor labor planning, Shortage of Equipment, Poor material planning, Unsuitable management structure, Poor process procedures, Project complexity, Harsh weather conditions and Unforeseen ground conditions. Similarly, (Steininger, et al., 2021) investigated the causes for the time overrun of the railway project Stuttgart21 and finds scope changes, geological conditions, high risk-taking propensity, extended implementation, price overshoot, conflict of interests and lack of citizens' participation are the major causes. According to (Adam, et al., 2015) Scheduling delays are typically divided into: (a) excusable delays; (b) compensable delays; and (c) non excusable delays. Compensable delays are those where the contractor is owed compensation for delays caused by an unwarranted course of action taken by the client. Non-excusable delays refer to delays caused by actions or lack of action by the contractor and where the client may be subject to compensation from the contractor. Most notably, late deliveries, damaged goods and poor planning were identified as the most influential factors in causing time delays. (Adam, et al., 2015) According to the response by contractors, the chief causes for delays were due to postponements in design information, lengthy duration for approving drawings

and inadequate site management. Conversely, consultants attributed delays primarily to unforeseen ground conditions, inadequate contractor experience and poor site management and supervision. Generally, the length of the delay is also dependent on the type of project undertaken, (Adam, et al., 2015) finds out Maintenance projects generally experience the most severe time delays, Causes identified as road maintenance projects are frequently associated with unpredictable and unforeseen site conditions that often require the relocation of utilities and redirection of traffic flow which in turn tends to result in significant time delays. According to (Steininger, et al., 2021) Geological conditions and unexpected underground obstacles leads to time overruns of mostly Large public infrastructure project. According to (Kaliba, et al., 2009) major causes of schedule delays in road construction projects in Zambia were changes in drawings & specifications, material procurement, construction mistakes, financial difficulties, delayed payments, labor disputes and strikes. According to (Mahamid, et al., 2012) list of delays causes is divided into 8 groups i.e., (1) Project group causes were Award project to lowest bid price, Disturbance to public activities, Limited construction area, Poor ground condition, Poor soil quality, Poor terrain condition, (2) Owner group causes were Progress payments delay, Delays in decision making, Poor communication with other construction parties, Unreasonable project time frame, Financial status, Delay in approving sample materials, , Late land handover, Change orders by owner during construction, Late issuing of approval documents, (3) Materials and equipment causes were lack of equipment efficiency, Shortage of equipment/materials, Changes in material types and specifications, (4) Laborers causes were low productivity of laborers, Insufficient laborers, Personal conflict between laborers and management team, Personal conflicts among laborers, (5) External group causes were Political situation, Exchange rate fluctuation, Weather condition, Monopoly, Natural disaster, (6) Design group causes were Late design works, Mistake in design, Inappropriate design, (7) Contractor group causes were Difficulties in financing project by contractor, Poor communication by contractor with other construction parties, Poor qualification of the contractors' technical staff, Delay in commencement, Improper construction method, (8) Consultant group causes were Inflexibility of consultant, Poor communication by consultant with other construction parties, Delay in performing inspection by consultant. For international projects (Ahsan & Gunawan, 2010) listed major causes of delay that is Lengthy procedure for contract evaluation and award, Procurement delay, Civil works and land acquisition delay, Consultant recruitment delay, Natural calamities, Government procedural delay, Local politics and economic problem, New scope addition, Frequent change of project staff(manager, director). As per (Famiyeh , et al., 2017) Unrealistic contract durations imposed by owner, Poorly defined scope, Slow decision-making, Delays in payments, Delay in Preparation and approval of drawings, Poor Site management, Inadequate contractor experience, Mistakes during construction, Bureaucracy in Government agencies, any discrepancies in contract documents, Changes in laws and regulations are some of the causes of delay in educational sector project in Ghana. In Malaysian construction, according to (Shehu, et al., 2014) Late payment from contractor to sub-contractors or suppliers, Contractors poor coordination with the parties involved in the project, Improper construction method, Shortage of technical professionals in the contractors organization, Excessive bureaucracy in the owners administration are major reasons for time overruns. (Marzouk & El-Rasas, 2014) conducted study in Egyptian construction industry and found that top 10 delay causing factors were type of project bidding and award (negotiation, lowest bidder), Ineffective planning and scheduling of project, Variation orders/changes of scope by owner during construction, Late in revising and approving design documents by owner, Finance and payments of completed work by owner, Poor site management and supervision, Low productivity level of labors, Difficulties in financing project by contractor, Effects of subsurface conditions (e.g., soil, high water table, etc.) low decision making. According to (Alsuliman, 2019) Common delay factors in Saudi Arabia for public projects were Lack of planning by government entities, Lack of accuracy in the studying of the site, Contractor's failure to study the site and tender in the exact form, focus on financial analysis and awarding the lowest bidder, Variation in orders occurs during the project period, Frequent disputes between project parties, Poor salaries and financial incentives for engineers lead to a lack of interest in study and supervision, Corruption in estimating

quantities, prices, costs, and supervision, the weakness of external financial and technical control (Alsuliman, 2019). Similarly, for the UAE Construction industry (Johnson & Babu, 2018) Design variation from client and consultant, Unrealistic schedules and completion dates projected by clients, Delay in obtaining government permits and approvals, Inaccurate time estimation by the consultants, Change orders from clients, Incomplete drawings and details provided by consultant, Poor planning and scheduling by consultants, Delay in client decision making process, Delayed payment to contractors, Prolonged procedures of inspections by consultants were major factors causing time overruns.

2.3 Causes of Cost and Time overruns in Indian Construction Industry

The size and the complexity of construction projects in India have drastically increased over a period. There are many infrastructure projects being executed in various locations. (Narayanan, et al., 2019) studies and analyses the time overrun and cost overrun in 30 mega infrastructure projects in India construction industry these projects represent different sectors such as road transport and highways, power, atomic energy, metro and urban development, petroleum, and petrochemicals. (Narayanan, et al., 2019) Infrastructure and construction sector represents around 10% of India's Gross Domestic Product. It provides direct or indirect employment to more than 30 million people. Hence, cost overruns and schedule delays in such public projects are not at all accepted, it is needed to pay attention to ensure efficient use of the taxpayer's money (Asiedu & Adaku, 2020). (Doloi , et al., 2012) performed factor analysis and identified most critical factors of construction delay in Indian construction projects were identified as (1) lack of commitment; (2) inefficient site management; (3) poor site coordination; (4) improper planning; (5) lack of clarity in project scope; (6) lack of communication; and (7) substandard contract. According to (Narayanan, et al., 2019) major factors for cost overruns in Indian construction industry majorly in infrastructure projects are identified as Inefficient Communication between project stakeholders, lack of knowledge/competence, poor project specific attributes, lack of cooperation, hostile socio-economic and climatic conditions, delayed decision making, aggressive competition during tendering and short bid preparation time. (Doloi , et al., 2012) also performed Regression modelling indicates that slow decision from owner, poor labour productivity, architects' reluctance for change and rework due to mistakes in construction are the reasons that affect the overall delay of the project significantly in Indian construction projects. According to (Narayanan, et al., 2019) Change in scope and change in market conditions are one of the main factors for cost and time overruns in Indian construction industry. It also noted by (Narayanan, et al., 2019) that the time overruns do not necessarily results in cost overruns. As per (Doloi , et al., 2012) research factors affecting delays in Indian construction project were (1) Lack of commitment. (2) Inefficient site management. (3) Poor Site coordination. (4) Improper Planning. (5) lack of clarity in project scope. (6) Lack of communication. (7) Sub-standard contract. (Narayanan, et al., 2019) Noted that the project with longer duration experience fewer cost overruns compared to the project with shorter duration. According to study of (WANJARI & DOBARIYA, 2016) some of the major factors causing cost overruns were Price escalation of raw material, delay in planned activity, lack of co-ordination between construction parties, frequent changes in design, poor financial control on site, mistake during construction, and force majeure. A Similarly study conducted by (Prasad, et al., 2019) where they categorized delay causes into 7 main categories as (a) Planning, design & engineering causes were Poor scope definition by contractor, Inadequate early planning of the project, Exceptionally low bids by contractor, Inadequate integration on project interfaces, Mistakes/changes in the design criteria provided by the employer, Unclear and inadequate details in drawings, Design changes by owner or his agent during construction, Design errors and omissions made by designers, Delays in producing design documents by contractor, Poor design with constructability problems (Prasad, et al., 2019). (b) Procurement causes were Shortages of materials, Shortage of equipment's of required capacity and numbers, Delay in delivery of imported materials and plant items (c) Financial causes were Delay in monthly payments from owners, Gap between construction costs & stage payments, Contractor's financial difficulties, Late payment from contractor to sub-contractors or suppliers, Delay in payment for extra work/variations by owner (d) Human Resource causes

were Poor labour productivity, Shortage of labours, Lack of skilled operators for specialized equipment's, Poor skills and experience of labour, Lack of experience/incompetence of Contractor's key staff (Prasad, et al., 2019). (e) Project execution causes were Delay in mobilization by the contractor, Lack of contractor's experience and control over project, Equipment breakdown and maintenance problem, Slowness of the owner's decision-making process, Rework due to errors during construction, Works in conflict with existing utilities, Site accidents due to negligence & lack of safety measures, Delay in Inspection and testing of completed portions of work (Prasad, et al., 2019). (f) contract management causes were Unrealistic contract duration imposed by owner, Ambiguity in specifications and conflicting interpretation by parties, Variation orders/changes of scope by owner during construction, Noncompliance with conditions of contract, Unreasonable risk allocation in contract (Prasad, et al., 2019). (g) External causes were High inflation, insurance and interest rates, public interruptions, Differing or unforeseen site/sub surface conditions, Changes in government regulations and laws. As per research study (Narayanan, et al., 2019) reveals that infrastructure projects in various sectors such as roads, railways, urban development, civil aviation, shipping, ports, and power have faced significant delays and cost overruns. Among these, road projects stand out with the highest instances of both time and cost overruns (Narayanan, et al., 2019). The primary reasons behind these delays and overruns include issues like land acquisition delays, forest clearance delays, law and order problems, price escalation, high capital costs, contractor performance issues, and equipment supply delays. Furthermore, there is a negative correlation between time and cost overruns and project budgets. Projects with larger budgets tend to have better construction planning, attract more stakeholder interest, and receive timely approvals and effective monitoring and control. After going through the we have identified Main key factors affecting cost and time overruns in Indian public sector at portfolio level (see, Table 1)*2.4 Identification of Main Key factors affecting Cost and Time overruns in Indian Public Sector at Portfolio Level*

Table 1 Key Main Factors affecting Cost & Time overruns in based on construction group in Indian public sector project at portfolio level

Sr no.	Factors Identified	Overruns	Groups	References
1	Inadequate financial planning and	Cost	Client	(Adam, et al., 2015) (Narayanan,
2	Slow decision-making process	Time	Client	(Mahamid, et al., 2012) (Asiedu
3	Change in Scope	Both	Client	(WANJARI & DOBARIYA,
4	Insufficient availability of utilities on site	Both	Client	-
5	Deficiency in Drawing	Time	Consultant	(Prasad, et al., 2019)
6	Poor communication and coordination	Both	Consultant	(Asiedu & Adaku, 2020)
7	Any discrepancies in contract documents	Both	Consultant	(Famiyeh , et al., 2017)
8	Any design changes	Both	Consultant	(Adam, et al., 2015)
9	Failure or Unavailability of equipment at	Time	Contractors	(Asiedu, , et al., 2017)
10	Mistakes and Reworks during execution	Both	Contractors	(WANJARI & DOBARIYA,
11	Poor coordination with subcontractors	Both	Contractors	(Narayanan, et al., 2019)
12	Shortage of skilled manpower	Time	Contractors	(Alsuliman, 2019) (Prasad, et al.,
13	Rise in the price of construction material	Cost	External	(Steininger, et al., 2021)
14	Any Political/Nonpolitical/Force majeure	Both	External	(Steininger, et al., 2021) (Ahsan
15	Inclement weather conditions	Time	External	(Prasad, et al., 2019) (Kaliba, et
16	Change in law, regulations, and	Both	External	(Famiyeh , et al., 2017)

III. RESEARCH METHODOLOGY

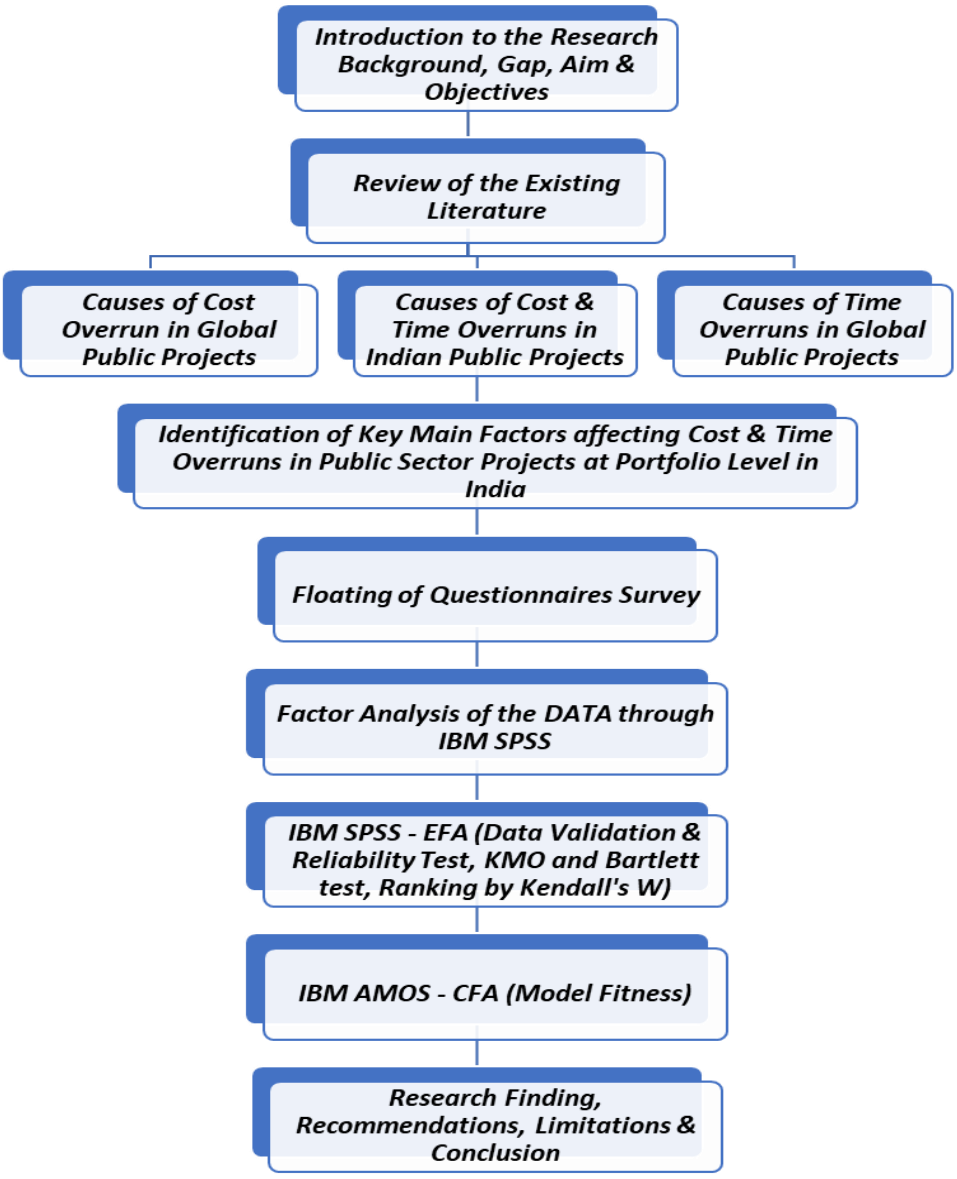

Figure 1 Research Methodology

3.1 Steps to be carried out in the methodology

- The criteria for selecting relevant literature included the use of papers published from 2009 to 2024, focusing on peer-reviewed journals and respected academic publishers. The selected papers must cover important subjects such as project portfolio, cost overrun, time overrun, public sector projects.
- Identification of the Key Main factors affecting Cost & Time overruns in public sector projects in India at Portfolio Level.
- Preparation of questionnaires based on the factors identified.
- Questionnaire was floated Respondents were asked to rate their answers on a 1–5 Likert scale, with one representing "Strongly Disagree," 2 for "Disagree," 3 for "Neutral," 4 for "Agree," and 5 for "Strongly Agree."
- The questionnaire consists of three sections. The first section focuses on Demographics such as which construction group they belong (Client, Contractor, or Consultant), Years of experience and their Respective

designation. The second section involves description of the topic. The third section is where the questions asked are based on factors identified i.e., Inadequate financial planning and budgetary limits (CL1), Slow decision-making process (CL2), Change in Scope (CL3), Insufficient availability of utilities on site (CL4), Deficiency in Drawing (C1), Poor communication and coordination with the contractor and other project stakeholders (C2), Any discrepancies in contract documents (C3), Any design changes (C4), Failure or Unavailability of equipment at project site (CO1), Mistakes and Reworks during execution (CO2), Poor coordination with subcontractors and suppliers (CO3), Shortage of skilled manpower (CO4), Rise in the price of construction material (EX1), Any Political/Nonpolitical/Force majeure events (EX2), Inclement weather conditions (EX3), Change in law, regulations, and bureaucracy from Government Authority (EX4).

- Questionnaires is Floated on Various Social Media Platform like LinkedIn to target industry professionals, Academic Scholar, Engineers, PMC, Public Professional Authority etc.

3.2 Sampling method and Size

Sample size, sampling method and sampling technique plays a major role in any survey research. If the sample size is inappropriate it may lead to wrong inferences on the population (Nanjundeswaraswamy & Divakar , 2021). For our Research, Cochran formula was used to calculate the essential sample size (see, Figure 2) for the required level of precision, confidence level and the estimated proportion of the attribute present in the population. Cochran formula is most suitable for a large population (Nanjundeswaraswamy & Divakar , 2021).

$$n_0 = \frac{Z^2 * p * q}{e^2}$$

Figure 2 Cochran's Formula for sample size

where n0 is the sample size, Z2 is the area under the acceptance region in a normal distribution (1 – α), e is the preferred level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1- p (Nanjundeswaraswamy & Divakar , 2021). We have computed from the above equation and we got roughly 289, representing the estimated sample size for our study. We obtained a total of 296 responses from the survey.

3.3 Quantitative Analysis

After collecting the required amount of data, under Quantitative analysis, Factorial analysis is performed on IBM SPSS software (Weaver & Maxwell, 2014). Under Exploratory Factor Analysis in IBM SPSS to check Data Validation & Cronbach's alpha reliability Test, Kaiser–Meyer–Olkin (KMO) test for sampling adequacy for each variable in the model and for the complete model and Bartlett test of sphericity and Ranking of the key main factors affecting cost & time overruns by Kendall's Coefficient of Concordance (Kendall's W) and under Confirmatory Factor Analysis in IBM AMOS for checking the Model Fitness.

IV. ANALYSIS & RESULTS

4.1 Demographics

Among the 296 responses received, 57.8% were from contractors, 19.6% were from individuals working in client firms, and 22.6% were from individuals working as consultants (see, Table 2 & Table 3)

Table 2 Designation of the Respondents

Designation	Total Respondents	Percentage
Accounts Manager	4	1%
Quality Control Manager	30	10%
General Manager	17	6%
Site Engineer	36	12%
Project Engineer	22	7%
Project Manager	39	13%
Project Director	22	7%
Project Coordinator	20	7%
Planning Manager	51	17%
Contracts manager	27	9%
Safety Officer	12	4%
Architect	6	2%
Others	3	1%
Quantity Surveyor	2	1%
Store Manager	3	1%
HR or Admin	2	1%

Table 3 Experience of the Respondents

Experience in Construction industry	Total Respondents	Percentage
2-5 Years	59	20%
6-10 Years	44	15%
11-15 Years	62	21%
16-20 Years	71	24%
20+ Years	60	20%

4.2 Reliability Test

A Reliability test of the data through descriptive statistical analysis is carried out to assess its validity for all 16 factors (variables) identified in the research (Weaver & Maxwell, 2014). A reliability test is conducted to ensure data accuracy. The efficiency of data reliability is measured using Cronbach's alpha score indexes in the study. A Cronbach score exceeding 0.8 indicates reliability for empirical research, while a score above 0.7 is deemed moderate. In this study, Cronbach's alpha was computed using software IBM SPSS. In our research, Cronbach's alpha score of 0.879 is achieved on the questionnaire data and is greater than the accepted score of 0.8. Thus, the internal consistency of the data is good and reliable, hence, data can be used for further analysis (see, Figure 3)

Reliability Statistics

Cronbach's Alpha	N of Items
.879	16

Figure 3 Cronbach's Alpha Score

4.3 Exploratory Factor analysis

For Sample Adequacy, Kaiser-Meyer-Olkin (KMO) Measure of sampling adequacy is computed through IBM SPSS software to determine the relevance of factors to the study (Weaver & Maxwell, 2014). This measure signifies the percentage of variance in the factors (variables) utilized in the study that are valuable for analysis. The software is also used to calculate the KMO and Bartlett's Test of sphericity, with results shown in (see, Figure 4)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.891
Bartlett's Test of Sphericity	Approx. Chi-Square	1559.360
	df	105
	Sig.	<.001

Figure 4 KMO and Bartlett's Test Result

Further for Factor Extraction, under EFA the most used method is Principal Component analysis (Mabel & Olayemi, 2020). This approach to factor analysis considers the total variance in the data. Hence, allowing for easier interpretation of the data. For Factor rotation, an orthogonal type Varimax rotation is a commonly utilized method due to the minimal correlation it produces in the outcomes (Mabel & Olayemi, 2020) it also assumes that factors are uncorrelated. In this research study, EFA is carried out using principal component analysis for factor extraction, followed by Varimax and Kaiser Normalization for factor rotation. The criterion for factor extraction is based on the eigenvalues of each factor, in which, with any factor having an eigenvalue less than 1 are being reduced or removed. Subsequently, factor rotation is performed, and factors are reduced or removed based on grouping and factor loading values. If the factor loading of a factor is below 0.5, it is reduced or removed. Initially, the rotation involved 3 components and 16 factors, but after factor reduction and one subsequent rotation, the 3 prominent components and 15 factors were identified with each having more than 0.50 factor loading as stated earlier.

Rotated Component Matrix[a]

	Component 1	2	3
EX3	.782		
EX2	.730		
EX1	.656		
EX4	.633		
CO3	.581		
CL1		.737	
CL4		.690	
CL2		.611	
C2		.593	
CL3		.567	
CO4		.554	
CO2		.516	
C4			.785
C1			.638
C3			.608

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.

Figure 5 Rotated Component Matrix

All the 3-components extracted have an Eigen value greater than or equal to 1. As shown in the table. Component 1 has an eigen value 5.710>1, Component

2 has the eigen value 1.313>1, and Component 3 has eigen value 1.201>1. we can state that the first 3 components in the analysis together account for 54.833 % of total variance of the study (see, Figure 6)

4.4 Kendall's Coefficient of Concordance (Kendall's W) Test

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.710	38.067	38.067	5.710	38.067	38.067	3.214	21.424	21.424
2	1.313	8.756	46.823	1.313	8.756	46.823	2.943	19.617	41.041
3	1.201	8.010	54.833	1.201	8.010	54.833	2.069	13.793	54.833
4	.921	6.143	60.976						
5	.826	5.506	66.482						
6	.720	4.799	71.280						
7	.715	4.765	76.045						
8	.634	4.228	80.273						
9	.565	3.765	84.037						
10	.532	3.549	87.587						
11	.466	3.109	90.696						
12	.397	2.648	93.344						
13	.363	2.423	95.767						
14	.335	2.233	97.999						
15	.300	2.001	100.000						

Extraction Method: Principal Component Analysis.

Figure 6 Total Variance of the Study

For Ranking of the Key main factors as shown in (see, Figure 7) we have used Kendall's W Test, the finding were out of 15 factors extracted through EFA, top 5 factors affecting are C2 (Consultant Factors) Poor communication and coordination with the contractor and other project stakeholders affect both cost and time overruns, CL2 (Client Factors) Slow decision-making process affect time overruns, CL3 (Client Factors) Change in scope can affect both cost and time overruns, EX2 (External Factors) Any Political/Nonpolitical/Force majeure events can affect both cost and time overruns and EX3 (External Factors) Inclement weather conditions can affect time overruns.

Kendall's W Test		
	Mean Rank	Rank
C2	9.71	1
CL2	9.61	2
CL3	9.16	3
EX2	9.08	4
EX3	8.94	5
CO4	8.30	6
EX4	8.12	7
EX1	8.09	8
CO2	8.02	9
CL1	7.91	10
CO3	7.46	11
CL4	7.22	12
C1	6.93	13
C4	6.65	14
C3	4.81	15

Figure 7 Ranking of the factor

4.5 Confirmatory Factor Analysis

For Confirmatory factor analysis IBM AMOS 26 version was used. The model undergoes confirmatory factor analysis to assess the index (model fit). The analysis determines whether the degree of model fit is satisfactory or not, the results are given (see, Figure 8) with the Cutoff Criteria (see, Figure 9) and Model fit diagram (see, Figure 10)

Measure	Estimate	Threshold	Interpretation
CMIN	191.989	--	--
DF	87.000	--	--
CMIN/DF	2.207	Between 1 and 3	Excellent
CFI	0.929	>0.95	Acceptable
RMSEA	0.064	<0.06	Acceptable
PClose	0.031	>0.05	Acceptable

Congratulations, your model fit is excellent!

Figure 8 Model Fitness Results

Cutoff Criteria*

Measure	Terrible	Acceptable	Excellent
CMIN/DF	> 5	> 3	> 1
CFI	<0.90	<0.95	>0.95
RMSEA	>0.08	>0.06	<0.06
PClose	<0.01	<0.05	>0.05

Figure 9 Cutoff Criteria for Model Fitness

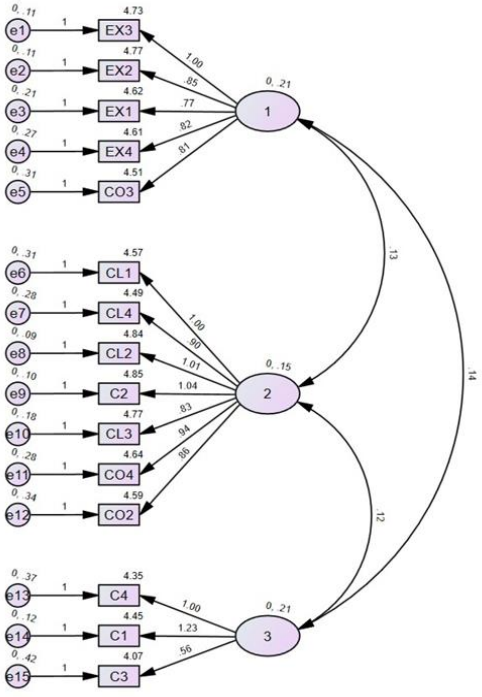

Figure 10 Model Fit Diagram

(See, Figure 10) The regression weights for Component 1 ranges from 0.77 (EX1) to 1.00 (EX3), for Component 2 ranges from 0.83 (CL3) to 1.04 (C2) and for Component 3 from 0.56 (C3) to 1.23 (C1). Similarly, the Intercepts for Component 1 ranges from 4.51 to 4.77, for Component 2 it is 4.49 to 4.85 and for Component 3 it is 4.07 to 4.45. The Covariance between Component 1 & Component 2 is 0.13 and Component 2 & Component 3 is 0.12 and Component 1 & Component 3 is 0.14.

For Model fitness Evaluation Summary:

1. Ratio of Chi-square min and Degree of freedom (CMIN/DF): 2.207 which is excellent (2.207 falls within the range of 1 & 3).
2. Comparative Fit index (CFI): 0.929 which is Acceptable (although 0.929 is not higher than 0.95, it could still be considered acceptable depending on an alternative criterion).
3. Root Mean Square error of approximation (RMSEA): 0.064 which is Acceptable.
4. Parsimony Measure (PClose): 0.031 which is acceptable (although 0.031 is not higher than 0.05, it could still be deemed acceptable based on an alternative criterion).

V. CONCLUSION

The study sought to understand the factors behind cost & time overruns of Indian public sector projects at Portfolio level. The finding of this study will facilitate construction professionals during different phases of project lifecycle to manage their projects activities and tasks efficiently and shall improve the performance of projects. As highlighted by (Adam, et al., 2017) the construction industry has been plagued by exceeding costs and delays in completion for many years. This issue is especially prevalent in large public projects, where going over budget and missing deadlines are common occurrences. Despite its expansion, the construction sector still faces obstacles like cost overruns, disputes, and delays. Developing countries like India encounter unique challenges due to global market conditions, scarce resources, insufficient skilled labor, and budget limitations. Current research primarily focuses on cost and time overruns at the project level, overlooking the wider perspective of project portfolios. This gap in literature inhibits the development of effective strategies and measures to prevent overruns in Indian public sector projects. Therefore, it is crucial to identify and evaluate the various factors causing cost and time overruns of Indian public sector projects at the portfolio level to ensure successful project objectives.

5.1 Objectives achieved

1. To identify and categorize the main key factors contributing to cost overruns in Indian public sector project at Portfolio:

By conducting a literature review, from different reputable journal to examine the main factors that contribute to cost overruns in public sector projects in India at portfolio level. A total of 19 papers were analysed to identify and categorize these key factors into different construction groups (see, Table 1 *Key Main Factors affecting Cost & Time overruns in based on construction group in Indian public sector project at portfolio level*)

2. To identify and categorize the main key factors contributing to time overruns in Indian public sector project at Portfolio.

Through Literature review of total 15 Paper key main factors affecting time overruns in Indian public sector project at Portfolio level were identify and categorized into different construction groups as shown (see, Table 1)

3. To develop questionnaire survey, collect Data from Industry professionals and to analyze the relationship between cost and time overruns and several variables (Main Key Factors) and rank the main key factors.

Questionnaires were developed based on (see, Table 1) factors identified through literature review and after receiving a substantial number of responses factor analysis was performed in IBM SPSS and based on Kendall's W test ranking was done (see, Figure 7. The top 5 factors affecting (see, Table 4) were from client related factors (CL2) Slow decision-making process affects time overruns and (CL3) Change in scope can affect both cost and time overruns. Consultant related factor (C2) Poor communication and coordination with the contractor and other project stakeholders affect both cost and time overruns and 2 factors from External Related EX2 Any Political/Nonpolitical/Force majeure events can affect both cost and time overruns and EX3 Inclement weather conditions can affect time overruns. Contractor-related factors are not present in the Top 5

affecting factors, but they do appear at the sixth rank (CO4) Shortage of skilled manpower can affect time overruns.

Table 4 Ranking of the factors based on Construction Group

Client Related Factors	CL1	7.91	10
	CL2	9.61	2
	CL3	9.16	3
	CL4	7.22	12
Consultant Related factors	C1	6.93	13
	C2	9.71	1
	C3	4.81	15
	C4	6.65	14
Contractor Related Factors	CO2	8.02	9
	CO3	7.46	11
	CO4	8.30	6
External Related Factors	EX1	8.09	8
	EX2	9.08	4
	EX3	8.94	5
	EX4	8.12	7

According to the ranking some of the factors have a lesser impact, most of them are from consultant related factor (see, Table 4) like (C3) Any discrepancies in contract documents can affect both cost and time overruns, (C4) Any design changes can affect both cost and time overruns, and (C1) Deficiency in drawings can cause time overruns.

4. A set of recommendations to avert cost overruns and time overruns is provided below.

5.2 Recommendations

1. Recommendations for the Top 5 Factors

In Consultant Related Factors Poor communication and coordination with the contractor and other project stakeholders can affect both cost and time overruns: -

- To improve communication in projects, establish communication channels and protocols for all stakeholders. Use project management tools like communication plans and digital collaboration platforms. Hold coordination meetings with everyone involved to discuss progress and address any issues. Encourage open dialogue and active participation for collaboration and problem-solving. Implement Building Information Modeling (BIM) technology for real-time sharing of design data. The aim is to establish an efficient and effective communication protocol between contractual parties during the design and supervision stages. Additionally, a strong and productive supply chain management system will be created. Identifying and understanding the barriers that impede effective communication among project stakeholders is crucial, and strategies to be developed to overcome them (Asiedu, , et al., 2017).

In Client Related Factors Slow decision-making process can cause time overruns: -

- Create a project schedule with milestones and decision points requiring client input. Emphasize the critical path and dependencies, stressing the need for timely decisions. Engage with the client early to establish decision-making expectations and the impact on project timeline. Delegate decision-making authority to client representatives, outlining responsibilities and escalation procedures. Maintain regular communication to update on project progress, upcoming decisions, and impacts of delays.

In Client Related Factors Change in scope can cause both cost and time overruns: -

- It is crucial to comprehensively define and document the project scope. This involves clarifying the client's expectations, objectives, and deliverables. To effectively manage changes in scope, a formal change management process should be established. This process should evaluate, review, and approve proposed changes, with clear procedures for submitting change requests and assessing their impact. It is also important to establish a scope baseline as a reference point. Robust scope control measures should be implemented to monitor and track scope changes, with open communication with the client. Ensuring project designs are fully completed before award of contract (Asiedu, , et al., 2017). Ensuring effects of any change order on construction cost and critical path (Asiedu, , et al., 2017) have been assessed and the necessary mitigating measures put in place.

In External Factors Any Political/Nonpolitical/Force majeure events can cause both cost and time overruns: -

- Conduct a comprehensive risk assessment to identify potential political, non-political, and force majeure events that may impact the project. Consider factors like geopolitical instability, regulatory changes, natural disasters, and economic volatility when evaluating risks. Create contingency plans that outline proactive measures to mitigate the impact of external events on project cost and schedule. Include contractual clauses addressing the allocation of risk and responsibility for external events among project stakeholders. Evaluate insurance options, such as construction all-risk (CAR) insurance, to mitigate financial risks associated with external events. Adopting e-procurement to ensure transparency (Asiedu, , et al., 2017).

In External Factors Inclement weather conditions can cause time overruns: -

- Use of AI technology for comprehensive weather analysis and forecasting to anticipate project-related risks. Monitor weather patterns and trends in the project area to identify high-risk periods. Create flexible schedules and plans that account for potential weather delays. Allocate buffer time for weather disruptions without affecting critical milestones. Include contractual provisions for managing weather-related schedule impacts.

2. Recommendations based on construction groups

a) For Client: -

The agreement should include a realistic timeframe for project completion. Ample time should be given for a feasibility study, financial planning, and obtaining necessary approvals and funding. A reputable project consultant should be chosen, and thorough tender documents should be ensured. Payments should be made to the contractor for ongoing work and milestones, following the contract terms. A reputable contractor with relevant experience should be engaged (Marzouk & El-Rasas, 2014).

b) For Consultant: -

Timely addressing the contractor's inquiries and promptly approving the submittals and shop drawings is essential (Marzouk & El-Rasas, 2014). Implementing a control system to manage, oversee, and assess variation orders, which are instigated by the owner, is crucial.

c) For Contractor: -

Creation of an extensive financial strategy and cash flow analysis. Establishment of a monitoring system for critical and long lead items, along with regular reporting and detailed explanations for any delays encountered. Selection of reputable subcontractors with ample experience (Marzouk & El-Rasas, 2014). Implementation of a robust site management and supervision system, as well as efficient project planning and scheduling.

3. General Recommendations for Indian Public sector at Portfolio level

I. Prior to finalizing the contract, negotiations must be conducted, solid contract agreements to be drafted, project schedules need to be established, and thorough documentation and record-keeping to be implemented to address delays and cost overruns.

II. Implementing a strong system for selecting contractors, adjusting payment schedules, and making payments based on market prices are among the strategies employed to address financial challenges faced by contractors (Prasad, et al., 2019).

III. Engaging in outsourcing with client approval, establishing flexible payment schedules, and securing supplies against bank guarantees are some of the strategies used to address delays in payments from contractors to suppliers/subcontractors (Prasad, et al., 2019).

IV. Developing clear clauses outlining scope changes, reviewing technical proposals from contractors, and conducting thorough site investigations were some of the steps taken to prevent delays in approving variations.

V. Conducting comprehensive pre-bid investigations, carrying out site visits, establishing a clear design philosophy and design management process, and setting timelines for design delivery are some of the measures taken to address design changes which further affect cost and time overruns.

5.3 Limitations of study

Despite the efforts made in this research and the valuable insights it has provided for the industry; The study has some limitations. The survey conducted for this study only involved three key stakeholders in

public sector construction projects, namely clients, consultants, and contractors in future scope of work the study should broaden to different project stakeholder groups, including materials suppliers, subcontractors, banks, and financial institutions, Government bodies, labor unions etc. Furthermore, the study is restricted to solely utilizing quantitative methodology. However, in future scope, it would be beneficial to incorporate both qualitative and quantitative approaches. By incorporating qualitative methods, such as conducting interviews with various individuals working in the public sector, a more comprehensive understanding can be achieved. The research also offers broad findings on public sector projects in India. For future studies, individuals should specifically focus on public projects like road projects, tunneling projects, hydropower projects, and so on.

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