Identification, and Assessment of Reasons for delay in Metro projects in India

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ABSTRACT
Transport solutions such as metro rail projects in cities are needed to cope with India's rapidly growing urbanisation. However, a number of issues that affect the performance in terms of deadlines, project costs and construction quality are faced by several metro projects currently under way in Indian cities. Based on the likely severity of these delays, this research prioritised time overrun parameters via expert questionnaire.
Relative importance index (RII) of collected responses were computed and analysed. The result show that for time overrun the top three critical factors are Existing Utility Shifting, Land Acquisition for the Project and Poor Management / Incompetency of Contractor.
It would facilitate the timely completion of metro projects with reasonable value for money to government, by mitigating this time overrun through proper life cycle contract management and risk allocation.

Keywords: Urban Metro Rail Projects, Time Overrun, Relative Importance Index (RII)

1. Introduction

India's expedition towards becoming an established nation by 2047 depends significantly on the improvement of its infrastructure, a keystone of the promotion of liveable, environment resilient and inclusive cities that drive financial growth. The government's assurance to the infrastructure sector in fiscal year 2024, which has a specific focus on transport and logistics, is illustrated by its 3.3% of GDP allocation.
With the goal of drastically altering this nation's infrastructure, the Indian government has embarked on a daring adventure to increase economic growth, fortify connectivity, and boost the standard of living for its people. The government has launched several ground-breaking programs aimed at enhancing city amenities, modernizing transportation networks, and building more digital infrastructure. These initiatives, which range from building roads, trains, and airports to supporting waterway and ropeway networks, are meant to advance equal development across the nation.
Over the past ten years, India's national highway system has progressive remarkably, thanks to enlarged funding allocation and structure speed. The budget for highways and road transportation has amplified by 500% since 2014, which has significantly enhanced infrastructure development. In 2020–21, the rate of highway creation reached an astounding 37 km/day, setting a record for India's fastest highway construction.
With 545 routes operationalized under the Ude Desh ka Aam Nagrik (UDAN), which aims to improve air connectivity to underserved regions, India's aviation sector has seen substantial progress. In addition to route growth, the government has designated 21 Greenfield Airports for development across the nation, 12 of which have been operationalized, demonstrating its commitment to improving the nation's aviation infrastructure. India's aviation system is expanding quickly, with 158 airports now in operation and 84 more being built in the last ten years. As of March 13, 2024, over 1.36 crore people had travelled there.
India's railway expansion demonstrates the government's dedication to improving transportation infrastructure for the advancement of the country and is a noteworthy step towards modernization and increased connectivity.
The Vande Bharat trains are a substantial upgrade in India's railway system, with greater safety features, quicker acceleration, and better passenger facilities. These trains provide a contented and suitable travel experience by featuring programmed plug doors, reclining ergonomic spaces, and mobile charging connections for each seat. As of January 31, 2024, over 100 Vande Bharat train services are active across Indian Railways, with a remarkable overall occupancy percentage of 96.62% in 2022-23.
The development of India's Metro Rail arrangement has transformed urban travel, with the network expected to grow

from 248 kilometres in 2014 to an astonishing 945 kilometres by 2024. This substantial expansion underscores Metro Rail's critical role in providing convenient transportation to metropolitan populations, with roughly 1 crore passengers using the system each day. From just five cities in 2014, the Metro Rail network now serves 21 across the country, with 919 kilometres of new lines underneath construction in 26 more cities. Furthermore, the overview of India's first State of the Art Namo Bharat train, operating on the Delhi-Meerut RRTS (Regional Rapid Transit System) line, underscores the nation's promise to improving regional connectivity and updating its transportation infrastructure.

Cities in India are expanding promptly. Direct growth that is planned and gives the transportation system enough consideration in the early stages of development is necessary. Cities are seeing a rapid increase in the number of personal motor vehicles, with severe congestion and pollution being the most obvious signs of this growth.

The public transportation system will need to be improved as part of any efforts to fix the issue. This would necessitate the implementation of mass transit systems in several cities, including metro rail, buses, rapid transit, light rail, etc. In recent years, India has experienced substantial progress in the development of urban rail, commonly referred to as metro rail. Metro rail is becoming more and more necessary in cities to meet daily mobility needs.

For the benefit of the public, metro projects need to be finished as soon as possible because they are a much more vital component of the city. In India, almost all metro projects are experiencing delays. The most frequent, complicated, and hazardous issue that arises in construction projects is generally regarded as delay, which causes both Excessive expenses and delays in completion. Time invades are a common feature of construction projects in emerging nations. Deadlines and uncertainty are burdens on all projects, regardless of their size and complexity. While delays in construction projects are foreseeable, the extent of these delays fluctuates significantly from project to project.

Natural disasters, such as floods and earthquakes, are the most frequent cause of delays in the construction industry. Other factors include issues with money and payments, poor planning, poor site management, a lack of experience, a shortage of supplies and equipment, and others. We discuss the causes of delays, their contributing factors, and some recommendations for minimizing them in metro construction projects.

The primary objective of this paper is to identify the primary causes of project delays and make suggestions for how to resolve or lessen their effects.

The relationship between new technology and time overrun in these projects is shown by the delay in construction projects. Many projects use outdated construction technologies, which is one of the main causes of delays; however, the impact of technology adoption on delays is ignored.

Unproductive construction planning is the second foremost factor in poor time performance. Although the impact of the contractor's incompetence on lack of commitment is very significant, neither of these two factors directly affect project time delays

2. Literature review

Few studies have been reported in past in similar areas and have been discussed here.

(Ahsan & Gunawan, 2010) determined that the hiring of consultants, lengthy contracts, procurement, civil works and land acquisition, and procurement were the main reasons for project delays. Two more significant factors contributing to project delays are bureaucracy in the host country and natural disasters. ID projects have significant problems, one of which is procurement. Procurement delays are frequently brought on by protracted bid evaluation periods, implementation companies' operational lags, and local authorities' lack of familiarity with foreign procurement. ID projects frequently take longer than expected because of drawn-out land acquisition complications brought on by regional politics, land law, and religious concerns. The impact of local government is an additional aspect that causes delays in projects.

(Kumar R, 2016) the most significant issue driving construction delays was identified as inadequate contractor work and experience, as well as poor risk management. The main explanation for all of these reasons is a lack of commitment and coordination among project participants. The level of dedication among project participants has a significant impact on the project's quality and progress. Delays in construction are frequent over the world, although their causes and effects vary depending on the native, location, and culture of the industry. Contractors should effectively plan and schedule the project in advance, considering all possible risk factors in terms of the character and culture of the location.

(K Pai & Bharath, 2013) found the ten most crucial factors for delays: project initial time duration, inefficient planning

and scheduling, faults and discrepancies in design papers, and delay in equipment supply.
(Mittal & Paul, 2018) identified the ten most crucial delay reasons from a list of 49 nominated criteria divided into seven categories. The identified factors included: (1) Delay in land acquisition and site handover to contractor, (2) Shifting of utilities and contingency works, (3) Scope change, (4) Payment delay, (5) Effects of unforeseen subsurface and changing ground condition, (6) Shortage of construction materials in the market, (7) Delays in design approvals and decision making, (8) Shortage of labor, (9) Lack of data collection and survey before design, and (10) Delay in obtaining permits.

(Doloi, Sawhney, & Rentala, 2012) This study demonstrates that one of the most important causes of building delays is a lack of commitment. Inefficient site management is undoubtedly another major element influencing the time performance of most building projects in India. This may be owing to a lack of formal training among site professionals, who typically build their supervisory skills through experience. Most notably, the importance of this element, albeit in various orders, has been revealed in prior study on cost performance context in Indian building projects.

Most Critical Parameter identified from Literature:

Sl. No.	Literature		Critical Parameter
1	Kamrul Ashan, Indra Gunawan (2010)	Analysis of Cost and Schedule performance of International Development Project	Project management & Contract management issues
2	Hemanta Doloi, Anil Sawhney (2012)	Analysing Factors affecting delays in Indian Construction Projects	Financial resource management
3	Aftab Hameed, (2012)	Time and Cost Performance in construction projects in Southern and Central regions of Malaysia	Design & Documents issues
4	Siddesh K Pai, J.Raj Bharath (2013)	Analysis of Critical Causes of Delays in Indian Infrastructure Project	Slow decision making
5	Ar. Meenva V, K.Suresh Babu (2015)	Study on Time Delay Analysis for Construction Project Delay Analysis	Increase in material/machine prices
6	Dinesh Kumar R (2016)	Causes and Effects of Delay in Indian Construction Projects	Inadequate contractor experience
7	Yash Kumar Mittal (2018)	Identification of Critical Factors for Delay in Metro Rail Projects in India	Land acquisition problem
8	Chhavi Gupta, Chitranjan Kumar (2020)	Study of Factors Causing Cost and Time Overrun in Construction Projects	Change in material specification
9	Akash Kokane, Rahul Shinde (2022)	To Analyse the Causes of Time and Cost Overrun in Pune Metro Project	Project management & Contract management issues
10	Kashi Nath Sharma (2023)	Study of risks in High Rise Building projects in india	Poor Contractor Performance

3. Methodology

A structured and well defined methodology is adopted in the present research work, which is shown as below (figure 1).

Stage	Description
Step 1	**Establishing Need of research**
Step 2	**Identification of Parameters of Delay**
Step 3	**Field Expert's Survey for Ranking Parameters**
Step 4	**Expert's Survey Conduction (Data Collection)**
Step 5	**Data Analysis and Ranking of parameters using RII**
Step 6	**Interpretation, Recommendation and Conclusion**

After detailed literature survey of related work regarding analysis of delay parameter attributable for delay in metro project, questionnaire was formulated for the survey. Several physical meetings were done with various project managers and working professional to compile the questionnaire. Based on literature review, physical interviews, telephonic interviews and practical experience, various parameters have been identified for the questionnaire. The drafted questionnaire has been attached in the annexure.

The questionnaire was posted to various professionals through email / Google survey link which represents the middle and senior level of various reputed organisation and working professional working in various running metro project in India. These professionals are having good experience of development of metro projects. After receiving the response, various parameters shall be ranked by calculating Relative Importance Index (RII). The parameter having highest RII shall be considered as rank 1 and least RII as last rank. Various parameters shall be then represented in descending order of its rank. Literature review and professional experience also confirms the same as major critical parameters.

4. Questionnaire structure

The questionnaire was to be filled by experts who are directly or indirectly involved in metro rail construction projects. The questionnaire was separated into two main parts. The Primary part captured details of the respondents, including their experience in the construction of metro rail projects. The second part was dedicated to rate effect of each of following adverse cause on duration of project.

For rating the parameters of delays in metro projects, a unidirectional 5-point Likert scale was used. The respondents were expected to rate each parameter on a severity level where '1' is for not significant, '2' for slightly significant, '3' for middle, '4' for very significant, '5' for extremely significant.

For e.g., if the parameter is Land acquisition for the project and it is rated 4 it would mean that land acquisition has very significant effect on duration of the metro rail project. The ratings are later used to compute the RII where the corresponding number was used as the weightage.

Sl. No.	Parameter for Delay in Metro Projects	Remarks
1	Land Acquisition for the Project	
2	Delays in Tendering and bidding process	
3	Financial Arrangements	
4	Public Resistance	
5	Unforeseen Site Conditions	
6	Change in Scope / Design	
7	External Infrastructure linkages/Utility shifting	
8	Inadequate Planning/Scheduling	
9	Shortage/Mismanagement of Materials & Equipment	
10	Shortage of skilled labour	
11	Lack of co-ordination between Stakeholders	
12	Delay of deliverables from Consultant & Sub Contractors	
13	Poor management/Incompetency of Contractor/Sub-Contractor	
14	Disputes/Legal issues	
15	Delay in payments	
16	Change in Government/Policies/Regulations	
17	Force Majeure	
18	Repeated revision of drawings and inputs	
19	Lack of Awareness of Modern technology	

4.1 Area of study

The Survey was carried out on professionals who are primarily involved in metro project and these professionals have a great deal of experience in the field of various metro projects in various metropolitan cities in India for construction of metro and urban infra projects.

4.2 Data collection

Nearly 52 experienced professionals have been identified for the questionnaire and total 52 responses have been recorded

4.3 Data analysis

The questionnaire survey was conducted to gain insights into reasons of delays as experienced by industry experts, including government authorities in charge, project managers, project engineers, various contractors, consultants and academic researchers. A google form open survey was conducted between 15th Nov -13th May 2024. Total 52 responses were received. The experts were questioned to mark the severity level of the factors for the parameters ranging from 1 to 5 (Not Significant to extremely significant). The table1 shows the number of responses (frequencies) received for each severity level for various parameters.

Calculation of RII (Relative Importance Index)

The relative Importance Index (RII) is calculated to rank the parameters constructed on the respondents' ratings on the 5-point Likert Scale of severity levels. Equation (1) is used for the computation (Davoodi and Dagli 2019).

$$RII = \frac{\sum_{i=1}^{5} Wi \times ni}{A \times N} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

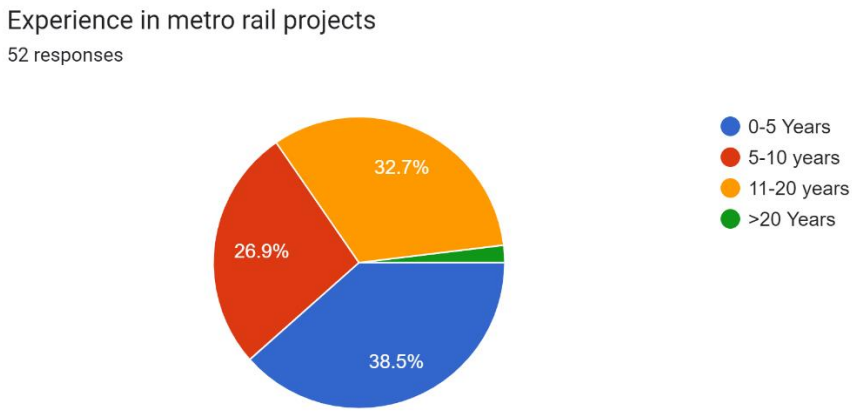
RII = Relative Importance Index for each parameter
i = Severity levels in the Likert Scale
W = Weightage for each severity level (range from 1 to 5)
n = Number of responses (frequencies) for each i severity level
A = Maximum weightage of a parameter (i.e., 5 in this case)

N = Total number of respondents
As the survey uses five levels of the Likert scale, the weights used for each severity level are as follows: '1'for not significant, '2' for slightly significant, '3' for middle, '4' for very significant and '5' for extremely significant. First, the weights are multiplied with the frequencies of responses for that severity level for each parameter. The multiplied values of all five severity levels are added to and the numerator. To find 'A x N' in this research, A is 5 (maximum weight) and N is 47 leading to A x N = 5 x 52 = 260

The RII was calculated for each parameter by dividing the numerator by the denominator (refer equation 1) as indicated in table 1. The maximum possible value of RII is '1'. A higher value of RII indicates that the particular parameter causes higher delays or cost escalation. Similarly, a lower RII value implies lesser effects of the parameter on delays or cost escalation. Hence, the importance of the parameter under scrutiny is indicated by a higher RII number. The ranks of the parameter are given based on the RII values, where parameters with higher RII values get the top ranks (smaller number). This method establishes the relative importance of affecting the project by the critical parameters as perceived by various experts

5. Result and discussion

Total 52 responses were received and all the respondents are directly or indirectly engaged in constructing metro rail in various cities of India. The respondent's bifurcation based on their experience in the metro rail project are tabulated in below pie chart: -



The responses that were received from the questionnaire were in one group, i.e., on the schedule delays. The Relative Importance Index (RII) value was determined using the above-mentioned method (refer) Calculation of RII (Relative Importance Index) to identify the most critical drivers of schedule extensions in metro rail construction.

Sl. No.	TIME OVERRUN FACTORS	Severity					RII	Rank
		1	2	3	4	5		
1	Land Acquisition for the Project	1	6	8	17	20	0.788	4
2	Delays in Tendering and bidding process	3	13	18	13	5	0.615	19
3	Financial Arrangements	3	6	15	13	15	0.719	14
4	Public Resistance	2	10	18	12	10	0.669	15
5	Unforeseen Site Conditions	3	6	12	19	12	0.719	13
6	Change in Scope / Design	1	3	15	16	17	0.773	6
7	External Infrastructure linkages/Utility shifting	0	3	8	22	19	0.819	1
8	Inadequate Planning/Scheduling	0	3	11	22	16	0.796	2
9	Shortage/Mismanagement of Materials & Equipment	3	5	11	18	15	0.742	10
10	Shortage of skilled labour	2	5	15	19	11	0.723	12
11	Lack of co-ordination between Stakeholders	1	6	11	22	12	0.746	9
12	Delay of deliverables from Consultant & Sub Contractors	0	5	13	20	14	0.765	7
13	Poor management/Incompetency of Contractor/Sub-Contractor	0	3	11	23	15	0.792	3
14	Disputes/Legal issues	0	5	15	14	18	0.773	5
15	Delay in payments	5	7	20	11	9	0.646	17
16	Change in Government/Policies/Regulations	3	7	19	16	7	0.665	16
17	Force Majeure	5	9	20	12	6	0.619	18
18	Repeated revision of drawings and inputs	1	5	12	21	13	0.754	8
19	Lack of Awareness of Modern technology	2	6	15	14	15	0.731	11

All variables were listed in order of decreasing RII value. Below in Tables 1, the responded frequencies for severity levels for the schedule delays and parameters, and their respective RII score and ranks w.r.t. each other are shown.

RANK	CRITICAL TIME OVERRUN FACTORS
1	External Infrastructure linkages/Utility shifting
2	Inadequate Planning/Scheduling
3	Poor management/Incompetency of Contractor/Sub-Contractor
4	Land Acquisition for the Project
5	Disputes/Legal issues
6	Change in Scope / Design
7	Delay of deliverables from Consultant & Sub Contractors
8	Repeated revision of drawings and inputs
9	Lack of co-ordination between Stakeholders
10	Shortage/Mismanagement of Materials & Equipment

Top 3 Critical factor identified are following:

1. External Infrastructure linkages/Utility shifting
2. Inadequate Planning/Scheduling
3. Poor Management / Incompetency of Contractor

The Survey result is very satisfactory and a most critical new parameter (Utility Shifting) has been identified for delay in metro project. 83% people in Survey have found the Utility shifting most attributable for delay in metro project.

The relocation of utilities and the implementation of contingency measures sometimes result in significant project delays. The primary cause of additional work and schedule deviations is the discrepancy between the estimated and mapped utilities in terms of their quantity and placement. The local authorities lack precise data regarding the location of utilities, which hinders the process of identifying them and leads to delays. These utilities may comprise subterranean water supply conduits, wastewater conduits, sewage network, power cables, and OFC (Optical Fibre Cable) line

Metro rail projects are taking a long time to complete as they involve a large number of stakeholders. During various stages of the project, problems like land acquisition, change in government policies, force majeure, etc. have a bad influence on the overall project health, thus ultimately leading to delays and budget escalation.

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Land Acquisition is one of the persistent problems not only in metro rail projects but other infrastructure projects as well. Metro rail being infused in already built urban areas, acquiring and assembling land from private owners and various government authorities is a tedious process. This problem can be seen in the construction of Bangalore phase 1, Delhi phase 3, Kolkata, Mumbai phase 1, Hyderabad metro. Miscommunication with the stakeholders and lack of clarity in contracts regarding the problem may result in disputes, further delaying the project. Sometimes, the compensation given to the original land holders is negotiated and increased to speed up the process, resulting in cost escalation

6. Recommendation for Critical Causes of Delay in Metro projects:

6.1 External Infrastructure linkages/Utility shifting

- A proper investigation or mapping should be conducted for Utilities before Tendering / Award of Work using GPR or any other Latest technologies
- Authority / owner should support contractor for Liasioning with utility agencies.
- Identification and removal of abandoned / defunct utilities
- Avoid utility relocation by change in alignment / change in footing size etc.
- Adopting Trenchless Technology

6.2 Inadequate Planning/Scheduling

- The planning & scheduling proposed by contractor should be checked by consultant that whether it's realistic or not and resources are well defined
- Advanced tracking method and software should be used
- Critical path should be monitored properly
- Proper work breakdown structure should be prepared and monitored

6.3 Poor Management / Incompetency of Contractor

- Bid evaluation process should be modified and increasing the QCBS (Quality cum cost-based

selection) method

- Strict guidelines or penalty should be imposed to contractor

Conclusion

This research provided key insights into the critical factors causing delays in urban metro rail projects through a questionnaire survey of experts involved in the said projects. The significant findings are as follows:

- 85% of the respondents reported that there are delays in the implementation of metro projects.
- Utility shifting id most critical factor for delay follow by inadequate planning / scheduling of the project, incompetency of the contractor.

  The actual reason for delays for particular projects were not studied in details in this research which is a limitation that may be addressed in the future research. Cost overrun with respect to the critical factor is recommended for the future research.

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