

IDENTIFICATION OF CRITICAL FACTORS FOR DELAY IN METRO RAIL PROJECTS IN INDIA

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Abstract

Purpose of the study: World over, transportation infrastructure projects face delays in commissioning and India is no exception. This study is carried out with an objective to specifically identify the critical delay factors in the commissioning of metro rail projects in India.

Methodology: A questionnaire survey was conducted to identify the major causes of delay from the opinion of clients, contractors and consultants. Calculation of Relative Importance Index (RII) for the shortlisted factors yielded the ranking. The ranking by various categories of respondents was analysed using Spearman's rank coefficient.

Main Findings: The study concluded in identification of 10 most critical delay-factors from a list of 49 shortlisted factors spread across 7 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) Delay in payments, (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 labour, (9) Lack of data collection and survey before design, and (10) Delay in obtaining permits from local body.

Implications: Project management interventions based on the identified critical factors of delay can improve the delivery of upcoming metro rail projects in terms of schedule compliance.

Applications of this study: The Application of suitable course correction measures targeting the critical factors can result in mitigation of delays.

Novelty/Originality of this study: The study is one of its kind attempt to investigate all the commissioned metro rail projects in India for analyzing delays in the Indian urban rail sector.

Keywords: Metro Rail Projects; Delay; Critical Factors; Ranking; Index

INTRODUCTION

Delay in Infrastructure Projects

The urban population of India stood at 31.16 % as per the 2011 census of India. It is projected to rise to 60 percent by the year 2050. To respond to this shifting trend, in the last decade, 8 metro rail projects have been commissioned in India to augment the provisions for public transport. Regardless of the importance and demand for metro rail projects as a means of public transport, issues like untimely completion and delays are common to the planning and execution of these projects. Poor project delivery in terms of time and cost adherence, in almost all the cases of metro projects, proves the case of volatile project performance. The factors of time, cost and quality with respect to Indian construction projects in different regions have been investigated from time to time. Whereas the performance evaluation of metro rail projects in the transportation sector, which equally fails to comply with the project performance standards, has not received the desired attention.

[Iyer & Jha \(2006\)](#) found that out of the set of studied projects in India, 40% were found to exhibit poor project performance in terms of time overrun. [Ahsan & Gunawan \(2010\)](#) studied the time performance of projects in a selected group of countries in Asia and found the time performance of Indian construction projects to be the poorest, with an average schedule overrun of 55%. [Vijayamohan Pillai & K P \(2003\)](#) studied 24 power projects in India and analysed the extent of time and cost overruns. The projects were reported with an average time overrun of more than 150%. [Bharath & Pai \(2013\)](#) in a similar study found that Bandra-Worli sea link project in Mumbai observed more than 400% cost overrun and five years of delay. [Singh \(2010\)](#) analysed the extent of cost and time overruns on a large set of infrastructure projects and reported that 445 out of the then going 925 projects were experiencing delays. In the study, projects spread across the seventeen sectors of infrastructure as categorised by the Ministry of Statistics and Programme Implementation, executed during 1992-2009, were found to exhibit an average time overrun of 125%. This validates the case of time overrun and cost overshoot in case of Indian infrastructure projects.

Time and cost overrun are also commonly observed in case of metro rail projects in India. Delhi metro project, commissioned in 2002, was the first modern metro project in India. The first phase of the project performed well in terms of schedule and cost compliance. The other commissioned projects in the last decade include Namma Metro, Rapid Metro, Mumbai Metro, Jaipur Metro, Chennai Metro, Kochi Metro and Hyderabad Metro. Almost all of these metro rail projects have faced delays

and ended up with substantial schedule overruns. With reference to such scale and frequency of delays in metro rail projects, it becomes significant to investigate the projects for identifying the factors responsible for the delay.

The studies conducted so far have discussed and analysed the factors related to delays of construction projects in the context of specific regions. Metro rail projects in India demand similar critical investigations. The number of upcoming projects and the issues during the pre-planning, planning and execution stages makes it imperative to identify the agents of delay, their contribution and the viewpoint of various stakeholders. Hence, this study focuses on the identification of critical delay factors and their ranking based on the opinion of different stakeholders.

LITERATURE REVIEW

Delay in projects

There is substantial literature available corresponding to delay in construction projects ranging from case examples of developing to developed nations. A majority of researches focus on the identification of critical factors and impacts of delay specific to a region. This study takes reference of the above mentioned category of works to derive a methodology for research.

[Assaf & Al-Hejji \(2006\)](#) examined the construction projects in Saudi Arabia using a questionnaire based study and the findings reported that 70 % of the considered construction projects failed to complete within the stipulated time. The most common factor responsible for the delay as identified by the owner, consultant and the contractor using questionnaire survey was "Change Order". In a study based in Nigeria, [Ajanlekoko \(1987\)](#) observed the schedule compliance in construction projects to be poor. [Ogunlana, Promkuntong & Jearkijrm \(1996\)](#) observed significant delays in Thailand whereas [Al-Momani \(2000\)](#) conducted an investigation of severe construction delays in Jordan.

Causes of delay

[Ahmed et al. \(2003\)](#) emphasized on the need to identify the causes of delay in construction industry in Florida and advocated that the delays could be mitigated by working on the identified causes. [Alaghbari et al. \(2007\)](#) reported the factors of delay in building construction projects in Malaysia by conducting an opinion survey on shortlisted 31 factors. This study measured the importance of factors classified in four categories –contractor factors, owner factors, consultant factors and external factors. [Mezher & Tawil \(1998\)](#) reported the important factors of delay in the study conducted for construction projects in Lebanon. Financial issues in case of owner, contractual relationships for a contractor and project management issues for consultant were identified as the most important factors of delay.

[Sambasivan & Soon \(2007\)](#) studied the factors of project delay and its repercussions on project completion in the Malaysian construction industry. The ten most significant causes of delay identified from a set of twenty eight different causes were (1) contractor's improper planning, (2) contractor's poor site management, (3) inadequate contractor experience, (4) inadequate client's finance and payments for completed work, (5) problems with subcontractors, (6) shortage in material, (7) labor supply, (8) equipment availability and failure, (9) lack of communication between parties, and (10) mistakes during the construction stage. [Memon et al. \(2014\)](#) studied the factors of time overrun in case of Malaysian construction industry and reported that frequent design changes; change in the scope of the project; financial difficulties of owner; delays in decision making; and unforeseen ground conditions as the most contributing factors.

[Al-Khalil & Al-Ghafly \(1999\)](#) determined the most important causes of delay in public utility projects in Saudi Arabia. The three parties i.e. Contractors, Consultants and Owners, were found to agree on the importance ranking of delay causes. [Koushki, Al-Rashid & Kartam \(2005\)](#) derived the three main causes of time-delays included changing orders, owners' financial constraints and owners' lack of experience in the construction projects in Kuwait. The findings of the study by [Faridi & El-Sayegh \(2006\)](#) mention that half of the construction projects face delays because of approval in construction drawings from authorities, poor pre-planning and slow decision making process. [Al-Momani \(2000\)](#) found out the major factors of delay as – poor design, harsh weather, changes in design, unforeseen site conditions, and late delivery. An investigation and interpretation of the findings from the mentioned set of studies in the Middle East region reveal that approval, scope change and poor project delivery (slow decision making) are the common factors affecting the project schedule performance.

[Iyer & Jha \(2006\)](#) investigated the factors affecting the project performance in the construction sector of India. The study revealed that 40% of the construction projects are experiencing schedule overruns. The outcome was based on a questionnaire survey of 55 shortlisted attributes followed by factor analysis of the data to derive the critical success and failure factors. The identified list of seven critical failure factors affecting the schedule performance comprise of - conflict among project participant, project manager's ignorance, hostile socioeconomic environment, owner's incompetence, the indecisiveness of project participants, harsh climatic condition at the site and project specific factor. [Desai & Bhatt \(2013\)](#) studied the critical causes of delay in Indian residential construction projects. The study accounted the most significant factors as- original contract duration was too short; legal disputes between various parties; ineffective delay penalties; delay in progress payments by the owner; and delay to furnish and deliver the site to the contractor by the owner.

[Frimpong, Oluwoye & Crawford \(2003\)](#) used the relative importance weight method to derive the relative importance of factors causing delay. [Sambasivan & Soon \(2007\)](#) calculated the relative importance index (RII) of the factors of the overall dataset and within various groups of responses. The index was used in the ranking of factors and comparison of the relative importance of the factors as perceived by the three groups of respondents i.e. clients, contractor and consultants. [Alaghbari et al. \(2007\)](#) used the mean score for ranking of factors causing delay. [Chan and Kumaraswamy \(1997\)](#) analysed and ranked the factors of time overruns in Hong Kong construction projects using RII. The research also compared the differing perceptions of delay factors with the outcome of similar studies in Saudi Arabia and Nigeria. [Kaliba, Muya & Mumba \(2009\)](#) worked out the causes of schedule delays and cost overruns in road construction projects in Zambia using RII. A questionnaire survey based study by [Doloi et al. \(2012\)](#) identified the key factors affecting delay in the Indian construction industry using RII. [Assaf, Al-Khalil & Al-Hazmi \(1995\)](#) categorised causes of delay in 9 groups and calculated their relative importance by conducting a survey. The study revealed that the contractor, owner and architects have a coherence in the ranking of individual delay factors. Whereas there existed a difference in opinion for ranking of groups of delay factors. [Alinaitwe, Apolot & Tindiwensi \(2013\)](#) studied the causes of time and cost performance in Uganda's public sector construction projects. The major identified causes of delay were- Change of work scope and/or changes in material specifications; High inflation, insurance and interest rates; Poor monitoring and control, due to incompetent and/or unreliable supervisors; Delayed payment to contractors, subcontractors and/or suppliers; and Fuel shortages. The study comprised of computation of frequency index, severity index and importance index followed by ranking of factors. The results were validated on a case study of civil aviation projects.

Literature review reveals that the set of critical factors causing delay are uncommon across the different geographical regions and sectors of infrastructure. This clearly highlights the need for investigation of causes of delay in sector specific infrastructure projects. As observed from the literature review, a common practice of deriving the critical factors of delay, based on the opinion of different stakeholders is used in this study.

METHODOLOGY

A questionnaire was designed to assess the perceptions of different stakeholders on the importance of factors of delay in metro rail projects executed in India. The first part of the questionnaire collected the respondent's background information, including the organization served, designation, stakeholder represented, experience and projects worked upon. The second part of the questionnaire focused on identifying the causes of delays in metro rail projects. The respondents were asked to rate the indicators of delay on a Likert scale. The input corresponding to the frequency of occurrence and severity of the impact of all the shortlisted factors was asked. The factors were arranged into the following eight categories:

1. Client contributed factors: Delay in payments, delay in land acquisition and site handover to the contractor, scope change, delay in obtaining permits from the local body, delays in design approvals and decision making, delays due to dissension between owners/co-owners, delay in performing final inspection and certification by a third party and delays occurred in compliance of regulations and statutory approvals.
2. Contractor contributed factors: Difficulties in financing project/company insolvency, rework due to errors, conflicts with other stakeholders, lack of planning and scheduling from the contractor, negotiations time lapse for the award of work, inadequate management and supervision, unavailability of land for the casting of prefabricated structures and delays due to sub-contractor's work.
3. Consultant/Designer contributed factors: Repeated revision of drawings and inputs, delay in approving overall designs and shop drawing, delay in performing site inspection and testing of material samples, lack of data collection and survey before design and delays in producing & issuing design documents.
4. Labour contributed factors: Shortage of labour, lack of skilled labour for high precision works, high labour wages insists to hire a low number of labour, unavailability of space for labour facilities and labour safety & health facilities.
5. Material contributed factors: Shortage of construction materials in market, delay in material delivery, transport issues in congestion hours, quality of procured material/reordering, lack of adequate space for storing materials on site and price/ fluctuation in material prices.
6. Equipment/ Technology related factors: Unanticipated equipment breakdown & their idle time, low productivity and efficiency of equipment, use of obsolete construction technology, limited mechanization due to cheap labour, availability of specialized equipment (launching girder, Tunnel Boring Machine, form traveller, etc.) and lack of expertise to operate specialized equipment.
7. External factors: Effects of unforeseen subsurface & changing ground condition, weather, climate and rain effects on construction activities, heavy traffic & overcrowding, accidents during construction, changes in government regulations & laws, civil unrest/public strikes, economic crisis, litigation & decision delays, poor rates due to aggressive competition at tender stage, shifting of utilities & contingency works and lack of communication & coordination amongst stakeholders.

The professionals with experience on rail based projects were considered as potential respondents for the questionnaire survey. The questionnaire was distributed to project managers, project engineers, directors, architects, structural consultants,

service consultants, etc. A five-point Likert scale from 0 (no occurrence) to 4 (very high occurrence) was adopted to receive the opinion of respondents for frequency of occurrence of factors. The same set of factors was surveyed against the parameter of severity of occurrence on a scale from 0 (no impact) to 4 (extreme impact). A pilot survey was conducted amongst professionals with work experience in rail based projects to consolidate the list of factors. Snowball sampling, under the category of non-probabilistic sampling techniques, was used to gather responses for the study. Out of the 389 received responses, 216 (55.5%) were from Owner, 93 (23.9%) were from Contractor and 80 (20.6%) from the Consultant.

Calculation of relative importance of factors

To assess the perception of various categories of respondents, this study followed the approach of calculation of RII as discussed in the literature review. The opinion of these groups was taken on a five-point Likert scale and relative importance indices (RII) were calculated for each factor as follows:

$$RII = \frac{\sum W}{A \times N}$$

- W Weightage for each factor by respondent (ranging from 0 to 4)
- A Maximum Weightage (i.e. 4 in this case)
- N Total Number of respondents

Higher value of RII indicates the importance of the factor under consideration. The calculated value of RII is used to rank the factors for the delay. The group-wise and aggregated ranking enabled to compare the importance of factors as comprehended from the opinion of various groups.

DATA ANALYSIS AND FINDINGS

Respondent's profile

The respondents' profile including stakeholders represented, occupational level and working experience are compiled in Table 1.

Table 1: Respondent's Profile

Demographic characteristic	Frequency	Percent
Sex		
Male	345	88.69
Female	44	11.31
Stakeholder Represented		
Owner	216	55.53
Contractor	93	23.91
Consultant	80	20.57
Occupational Level		
Engineer	161	41.39
Architect	24	6.17
Administrative	36	9.25
Managerial	168	43.19
Working experience		
Less than 5 years	112	28.79
5-10 years	148	38.05
10- 20 years	74	19.02
More than 20 years	55	14.14

Ranking of Factors

The data collected from the questionnaire is categorized into three sets based on the stakeholder represented by the respondent (i.e. clients, consultants and contractors). RII value for all the factors was calculated for the identification of the most critical factors of delay in metro rail projects. The factors were listed in the decreasing order of their value of RII and ranked. The five most critical factors of delay from the perspective of clients were: (1) delay in land acquisition and site handover to the contractor (RII = 2.31); (2) shifting in utilities and contingency works (RII = 0.97); (3) scope change (RII = 0.93); (4) delay in payments (RII = 0.76); (5) effects of unforeseen subsurface and changing ground condition (RII = 0.71). The five most critical factors of delay from the perspective of contractor were: (1) delay in land acquisition and site handover to the contractor (RII = 2.27); (2) delay in payments (RII = 1.17); (3) shifting of utilities and contingency works (RII = 1.01); (4) scope change (RII = 0.89); (5) effects of unforeseen subsurface and changing ground condition (RII = 0.78). The five most critical factors of delay from the perspective of the consultant/ designer were: (1) delay in land acquisition and site handover to the contractor (RII = 2.26); (2) scope change (RII = 1.17); (3) delay in payments (RII = 0.99); (4) shifting of utilities and contingency works (RII = 0.95); (5) effects of unforeseen subsurface and changing ground condition (RII = 0.66).

The analysis of the critical factors from the perspective of client, contractors and consultants/designers indicates that delay in land acquisition and site handover to contractor is the most critical factor in delay. The opinion of contractors suggests that delay in payments is the second most responsible factor for delays. Delay in payments is an outcome of overshoot in time for processing of payments to contractors, sub-contractors, consultants and designers. In some cases, withdraw or change in structure of funding results into delay of payments. Shifting of utilities, scope change and effects of unforeseen subsurface and changing ground condition are the other most critical factors of delay as per the opinion of clients, contractors and consultants. During the construction phase of the projects, unaccounted utilities are detected during excavation. These are supposed to be either shifted or treated accordingly to suit the construction. The shifting of utilities and similar contingency works result in delays and adversely affect the schedule performance of metro projects. Metro rail projects are characterized by long durations and involves multiple stakeholders. These projects are prone to change in scope during different stages of the project. Scope change leads to revision in terms and condition of the contract, revision in drawings and other specifications, financial restructuring, etc. These all tend to have a negative impact on the schedule compliance of the project and intensify delays. Metro rail projects are also prone to the effect of unforeseen subsurface and changing ground condition. At times, a difference in the expected and actual subsurface and ground conditions is observed, which requires necessary course correction and results in delays. Table 2 presents the ranking of factors based on the overall responses.

Table 2: Ranking of factors (based on overall)

Cause of Delay	Percentage of respondents scoring (Occurrence)					Percentage of respondents scoring (Severity)					RII	Ranking
	0	1	2	3	4	0	1	2	3	4		
Owner Contributed Factors												
Delay in payments	5.9	54.5	21.1	15.9	2.6	1.5	42.2	23.1	26.5	6.7	0.915	4
Delay in land acquisition and site handover to contractor	0.3	8.5	18.8	49.4	23.1	0.0	2.6	13.6	56.0	27.8	2.299	1
Scope Change	4.4	41.4	39.3	14.1	0.8	0.3	19.8	47.0	27.0	5.9	0.974	3
Delay in obtaining permits from local bodies	14.9	48.6	32.9	3.1	0.5	6.2	52.2	31.6	8.7	1.3	0.553	10
Delays in design approvals and decision making	32.6	40.6	14.7	11.3	0.8	8.5	56.6	14.9	18.3	1.8	0.582	7
Delays due to dissension between owners/co-owners	21.6	60.7	17.0	0.8	0.0	2.3	71.2	22.9	1.5	2.1	0.356	27
Delay in performing final inspection and certification by a third party	30.6	46.5	14.4	7.5	1.0	6.7	60.4	21.3	11.1	0.5	0.475	17
Delays occurred in compliance of regulations and statutory approvals	30.8	50.4	16.5	2.1	0.3	7.5	64.8	22.9	4.4	0.5	0.370	25
Contractor Contributed Factors												
Difficulties in financing project/company insolvency	29.6	49.6	16.5	3.9	0.5	1.5	60.2	23.4	11.3	3.6	0.488	14
Rework due to errors	3.1	78.9	15.2	2.6	0.3	1.3	51.4	37.3	9.8	0.3	0.492	13
Conflicts with other stakeholders	35.0	47.3	14.4	3.3	0.0	8.2	68.1	18.3	5.4	0.0	0.353	29
Lack of planning and scheduling from contractor	12.1	72.0	14.7	1.3	0.0	2.6	76.1	18.0	2.8	0.5	0.355	28
Negotiations time lapse for award of work	16.7	75.1	6.9	0.8	0.5	1.5	73.3	16.2	8.2	0.8	0.339	31
Inadequate management and supervision	39.6	49.1	10.3	0.8	0.3	7.7	73.8	14.1	3.6	0.8	0.281	39

Unavailability of Land for casting of prefabricated structures	39.8	41.4	6.9	11.6	0.3	9.3	65.6	7.5	13.4	4.4	0.517	12
Delays due to sub-contractor's work	16.2	76.1	4.4	3.3	0.0	3.1	65.6	24.4	6.9	0.0	0.352	30
Consultant /Designer Contributed Factors												
Repeated revision of drawings and inputs	24.9	47.8	23.7	2.8	0.8	0.8	60.2	31.9	6.4	0.8	0.472	18
Delay in approving overall designs and shop drawing	32.1	59.6	4.9	2.6	0.8	32.6	51.9	9.8	4.9	0.8	0.249	44
Delaying in performing site inspection & testing of material samples	33.2	56.6	9.5	0.5	0.3	17.0	67.6	6.7	8.5	0.3	0.265	41
Lack of data collection and survey before design	23.1	45.2	25.4	5.7	0.5	1.0	51.9	34.2	12.3	0.5	0.561	9
Delays in producing and issuing design documents	51.4	42.7	5.7	0.0	0.3	1.0	65.3	25.7	7.7	0.3	0.199	48
Labour Contributed Factors												
Shortage of labour	24.2	41.6	23.1	11.1	0.0	6.4	53.2	30.3	9.8	0.3	0.567	8
Lack of skilled labour for high precision works	36.2	53.7	7.5	2.3	0.3	10.5	71.7	11.8	5.4	0.5	0.294	37
High labour wages insist to hire a low number of labourers	33.4	58.6	7.5	0.5	0.0	19.8	58.9	13.9	7.5	0.0	0.206	47
Unavailability of space for labour facilities	31.9	56.0	11.1	1.0	0.0	33.4	49.9	6.2	10.5	0.0	0.244	45
Labour Safety & health problems	40.1	47.3	10.5	1.8	0.3	30.8	53.5	9.0	5.9	0.8	0.283	38
Material Contributed Factors												
Shortage of construction materials in market	23.4	39.1	35.0	2.6	0.0	1.3	45.8	39.3	12.9	0.8	0.585	6
Delay in material delivery especially while importing	28.0	49.6	21.6	0.8	0.0	0.5	61.7	27.5	10.3	0.0	0.425	22
Material transport issues in congestion hours during day	29.0	47.8	18.8	4.4	0.0	0.8	64.0	27.8	7.5	0.0	0.432	21
Quality of procured material/reordering	38.6	50.6	10.3	0.3	0.3	11.6	70.2	16.5	1.3	0.5	0.264	42
lack of adequate space for storing materials on site	11.6	73.0	14.4	1.0	0.0	2.1	58.6	30.8	8.2	0.3	0.420	24
Price fluctuation/inflation in material prices	7.7	60.2	30.3	1.8	0.0	0.5	41.1	54.2	3.9	0.3	0.536	11
Equipment/ Technology related Factors												
Unanticipated Equipment breakdown and their idle time	30.8	40.9	24.9	2.8	0.5	9.8	61.4	20.3	5.9	2.6	0.449	20
Low productivity and efficiency of equipment	32.4	58.9	7.5	1.0	0.3	2.1	57.1	29.0	10.8	1.0	0.329	32
Use of Obsolete Construction Technology	42.4	55.3	1.8	0.3	0.3	4.6	68.1	21.6	5.7	0.0	0.192	49
Limited mechanization due to cheap labour	35.5	55.0	8.7	0.5	0.3	8.5	54.8	26.7	9.5	0.5	0.313	34
Availability of specialized equipment, i.e. Launching girder, TBM, form traveller.	39.6	48.3	10.3	1.3	0.5	10.3	68.9	12.6	7.7	0.5	0.316	33
Lack of expertise to operate specialized equipment	35.0	45.0	19.5	0.5	0.0	10.3	49.4	28.3	11.8	0.3	0.366	26
External Factors												
Effects of unforeseen subsurface and changing ground condition	19.3	38.6	37.5	4.1	0.5	4.9	37.5	35.0	17.7	4.9	0.724	5
Weather, climate & rain effects on construction activities	35.5	49.1	13.4	1.8	0.3	9.3	71.5	16.2	2.1	1.0	0.301	35
Heavy traffic, over-crowd & other restrictions on site	33.4	44.0	15.2	6.2	1.3	8.7	66.3	19.5	4.6	0.8	0.420	23
Accidents during construction	41.4	53.0	5.1	0.3	0.3	10.3	74.6	8.5	3.6	3.1	0.243	46
Changes in government regulations and laws	26.0	47.6	24.7	1.5	0.3	4.6	52.4	35.0	7.5	0.5	0.480	15
Civil unrest/public strikes	43.2	50.6	2.6	2.8	0.8	7.5	75.3	9.5	6.7	1.0	0.279	40
Economic crisis	38.3	54.5	6.4	0.5	0.3	9.0	73.5	14.4	2.6	0.5	0.252	43
Litigation and decision delays	29.8	43.7	20.6	4.9	1.0	5.9	62.2	23.7	6.7	1.5	0.479	16
Poor rates due to Aggressive competition at tender stage	25.4	47.6	25.7	0.8	0.5	9.8	47.3	31.4	10.5	1.0	0.452	19

Shifting of utilities and contingency works	14.9	29.3	42.2	12.6	1.0	3.1	28.0	30.6	32.4	5.9	0.983	2
Lack of communication and coordination amongst stakeholders	37.5	50.1	10.5	1.5	0.3	9.5	71.0	15.7	2.8	1.0	0.294	36

Table 3: Comparison of Ranking of Critical factors

S. No.	Factor Label	Cause of delays	Ranking			
			Over all	Client	Contractor	Consultant
1	F2	Delay in land acquisition and site handover to contractor	1	1	1	1
2	F48	Shifting of utilities and contingency works	2	2	3	4
3	F3	Scope Change	3	3	4	2
4	F1	Delay in payments	4	4	2	3
5	F39	Effects of unforeseen subsurface and changing ground condition	5	5	5	5
6	F27	Shortage of construction materials in market	6	7	9	12
7	F5	Delays in design approvals and decision making	7	10	7	7
8	F22	Shortage of labour	8	6	29	11
9	F20	Lack of data collection and survey before design	9	9	6	27
10	F4	Delay in obtaining permits from local bodies	10	12	12	6
11	F32	Price fluctuation/inflation in material prices	11	13	11	8
12	F15	Unavailability of Land for casting of prefabricated structures	12	8	18	21
13	F10	Rework due to errors	13	17	10	10
14	F9	Difficulties in financing project/company insolvency	14	11	24	15
15	F43	Changes in government regulations and laws	15	14	19	18

Ranking of Category of factors

Table 4 summarizes the RII and ranking of categories of factors of delay. Owner contributed factors are ranked first in the list of seven categories with an overall RII score of 0.815 as shown in the Table 4. Shifting of utilities, contingency works, and effect of unforeseen subsurface and changing ground conditions contributes as the external factors of delay. These factors are rated high in the survey and the category is the second most critical for the occurrence of delays. Shortage of construction materials in the market leads to significant contribution in delay of projects. Therefore, material related factors are also ranked high and stands third in the ranking of categories. The other categories have less than 0.4 values of RII and have comparatively less influence on schedule overruns. These categories include contractor contributed factors, consultant contributed factors, equipment/technology related factors and labour related factors.

Table 4: Ranking and RII- Category of factors

No.	Categories	Over all		Client		Contractor		Consultant	
		RII	Ranking	RII	Ranking	RII	Ranking	RII	Ranking
1	Owner Contributed Factors	0.815	1	0.789	1	0.843	1	0.840	1
2	Contractor Contributed Factors	0.397	4	0.427	4	0.350	5	0.370	4
3	Consultant /Designer Contributed Factors	0.349	5	0.372	5	0.353	4	0.277	7
4	Labour Contributed Factors	0.319	7	0.354	6	0.268	7	0.279	6
5	Material Contributed Factors	0.444	3	0.459	3	0.431	3	0.409	2
6	Equipment/ Technology related Factors	0.327	6	0.328	7	0.345	6	0.302	5
7	External Factors	0.446	2	0.464	2	0.435	2	0.407	3

Correlation Analysis

A correlation analysis is performed to check the concurrence in the opinion of the category of respondents. Table 5 presents the Spearman's rank correlation coefficient for the set of data. High correlation indicates that there is a high degree of concurrence between the categories of respondents. The results indicate that the view of all the three categories of respondents is positively correlated and are significant. The value of Spearman's coefficient is more than 0.6 in all the cases. Maximum

concurrence is observed in the opinion of client and consultant with a value of Spearman's rho (ρ) = 0.901. Whereas the value of ρ for the opinion of the consultant-contractor and contractor-client is 0.875 and 0.862 respectively.

Table 5: Spearman's Rank and Correlation Analysis

			Correlations		
			Client	Contractor	Consultant
Spearman's rho	Client	Correlation Coefficient	1.000	.862**	.901**
		Sig. (2-tailed)	.	.000	.000
		N	49	49	49
	Contractor	Correlation Coefficient	.862**	1.000	.875**
		Sig. (2-tailed)	.000	.	.000
		N	49	49	49
	Consultant	Correlation Coefficient	.901**	.875**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	49	49	49
**. Correlation is significant at the 0.01 level (2-tailed).					

DISCUSSION OF RESULTS

The ten most critical factors of delays (based on all respondents) as shown in the Table 2 are: (1) delay in land acquisition and site handover to contractor (RII = 2.298), (2) shifting of utilities and contingency works (RII = 0.982), (3) scope change (RII = 0.973), (4) delay in payments (RII = 0.914), (5) effects of unforeseen subsurface and changing ground condition (RII = 0.724), (6) shortage in construction material (RII = 0.585), (7) delays in design approvals and decision making (RII = 0.581), (8) shortage of labour (RII = 0.566), (9) lack of data collection and survey before design (RII = 0.561), and (10) delay in obtaining permits from local body (RII = 0.552). This section discusses the details of the critical factors of delay in metro rail projects.

Delay in land acquisition and site handover to contractor

Unavailability of land affects the timely implementation of construction projects. The issues of land scarcity and difficulty in land acquisition have affected metro rail projects in Delhi, Chennai, Kochi, Mumbai and Ahmedabad. This factor is even evident in the Delhi metro project, which otherwise presented a successful project delivery in the first two phases. Progress of Pink Line – Delhi Metro suffered, where 4 km stretch in Trilokpuri is struck over land acquisition issues including rehabilitation of affected people. In case of Hyderabad Metro, property acquisition issues in Line 3- Blue Line –Nagole to Raidurg are causing delays.

Shifting of utilities and contingency works

Shifting of utilities and contingency works frequently lead to substantial delays in the project. Variation in number and location of utilities from the estimated and mapped utilities on drawings is the major cause of extra work and affects the schedule compliance. These utilities may include underground water supply lines, waste water lines, sewage network, electricity cables, OFC (Optical Fibre Cable) line, etc.

Scope change

Change in plans by owner in reference to responding to the changing demands and scope of the project leads to project delays. The main causes of scope change are changes in technology, change in government regulations, financial issues, etc. In other cases, lack of clearly defined project scope during the project formulation stage also leads to significant delays. Addition and alteration in the alignment of track affecting the scope of work are found to be the major causes of delay in metro rail projects.

Delay in payments

Delay in payments to contractors and subcontractors affect cash flows during project execution. It affects the construction supply chain negatively. Delay in payments leads to litigation and disputes which are often resolved through negotiation and sometimes through arbitration. The other consequences of delay in payments are decreased productivity, increase in costs related to time overrun and re-scheduling of project activities which ultimately prevents the completion of projects on time.

Effects of unforeseen subsurface and changing ground condition

The project is affected by two types of changing ground conditions. The first includes the cases when the contractor encounters subsurface or latent physical conditions that differ materially from those indicated in the contract. The other cases include the instances when the contractor faces unknown and unexpected ground conditions that are materially different from those already encountered. The most common encounters in case of construction of metro projects are during excavation of underground networks and stations.



Shortage in construction material

Unavailability of aggregates including metal and sand is a challenge in construction of metro rail projects. The mining departments in the respective states have imposed stringent rules over the last few years leading to unavailability of rock aggregates. Such shortage of coarse and fine aggregates adversely affects the progress of ongoing construction works and causes delay. Projects experiencing substantial delays as a result of shortage of materials include Jaipur Metro Phase 1B and Kochi Metro. Shortage of materials is also caused by poor estimation, inconsistent demand and need for special materials during construction.

Delays in design approvals and decision making

Approval process, incomplete design drawings, irregular changes in drawings and specifications, discord amongst the approving authorities, etc. are the leading reasons behind delays in design approvals. Non adherence to standards, codes and regulations also causes delay during the scrutiny and approvals by the concerned authorities. In some cases, exploration and comparison of alternatives by the approving authorities, which involves extra time to incorporate the details of the revised proposal, lead to delays.

Shortage of labour

Construction of projects is frequently struck by shortage in labour. In agriculture based economies, migrant seasonal workers lead to unavailability of labour in the harvesting season. They are a major cause of delay for most of the construction based projects in India. Labour crisis also occurs due to the low number of new entrants, low wages, skill mismatch and geographic location based issues. Shortage of skilled labour also contributes to project delays in the construction industry. Metro rail projects are more affected by the shortage of unskilled labour.

Lack of data collection and survey before design

Project scheduling is done based on the identified project components, the available resources and the time required to complete the activities. The variation in quantum of work may lead to incorrect or unrealistic schedule and may lead to extensive delays. Lack of data collection and survey can lead to undesired and incorrect provisions and specifications of the project. In case, the collected and surveyed data is found to have deviated from the actual, the design specifications require up-gradation, revision and a complete change in some cases. This requires extra time and effort which leads to project delays.

Delay in obtaining permits from local bodies

Obtaining permits for construction and allied activities is a complex and time consuming process. It involves multiple authorities and agencies. The duration of time required in obtaining permits from local bodies and authorities is uncertain. The time involved in approvals from authorities vary largely with respect to location of projects as the procedure followed and the number of approvals required are different for different administrative settings.

CONCLUSION

Metro rail projects are helpful in augmentation of public transport infrastructure. These projects are frequently characterized by time and cost overruns. The aspect of time overrun is undertaken for investigation in this research. Progress of a metro rail project is typically influenced by multiple impediments. These impediments can be an outcome of factors related to owner, contractor, consultant, materials issues, labour issues, technology related aspects and external agents. A systematic evaluation of the causes of delay is expected to identify the project delay factors in the overall planning, construction and commissioning phases of a project. The paper presents the results of a study on the identification of critical delay factors, their importance, and ranking for the case of metro rail projects in India. Based on a total of 49 factors, a questionnaire was designed to gather the opinion of professionals with experience in rail based projects. Data from the survey was analysed using the Relative Importance Index (RII) and factors of delay were ranked. RII represented the degree of importance assigned to the factors of delay. The RII of 49 factors suggests that 1) Delay in land acquisition and site handover to contractor; 2) Shifting of utilities and contingency works and 3) Scope change are the three top critical factors of delay in metro rail projects. A ranking based on the category of factors was also derived. Owner, material and external related factors were found to be the major categories responsible for the delay. To compare the viewpoints of different participants, Spearman's rho was calculated from the processed data. The values suggest that the contractor and consultant have maximum concurrence in opinion with a value of Spearman's rho (ρ) = 0.901.

LIMITATION AND STUDY FORWARD

Further, the analysis of the identified factors of delay can be taken up in future research from the view-point of identification of project risks. Also, projects pertaining to the other sectors of infrastructure can be investigated to find out the causes of delay and their mitigation strategies.

CONFLICT OF INTEREST AND ETHICAL STANDARDS

There is no conflict of interest with current organisation and no unethical practices followed during the study. (Like plagiarism, animal testing, human testing etc.)

REFERENCES

1. Ahmed, S., Azhar, S., Kappagantula, P., & Dharam, G. (2003). Delays in Construction: A Brief Study of the Florida Construction Industry. *ASC Proceedings of the 39th Annual Conference Clemson University*, (pp. pp 257--266).
2. Ahsan, K., & Gunawan, I. (2010). Analysis of cost and schedule performance of international development projects. *International Journal of Project Management*, 28(1), 68-78.
3. Ajanlekoko, J. O. (1987). Controlling Cost in the Construction Industry. *Lagos QS Digest*, pp. 8-12.
4. Alaghbari, W., Razali A. Kadir, M., Salim, A., & Ernawati. (2007). The significant factors causing delay of building construction projects in Malaysia. *Engineering, Construction and Architectural Management*, 14(2), 192-206.
5. Alinaitwe, H., Apolot, R., & Tindiwensi, D. (2013). Investigation into the causes of delays and cost overruns in Uganda's public sector construction projects. *Journal of Construction in Developing Countries*, 18(2), 33-47.
6. Al-Khalil, M., & Al-Ghafly, M. (1999). Important causes of delay in public utility projects in Saudi Arabia. *Construction Management and Economics*, 17(5), 647-655.
7. Al-Momani, A. (2000). Construction delay: A quantitative analysis. *International Journal of Project Management*, 18(1), 51-59.
8. Assaf, S., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, 24(4), 349-357.
9. Assaf, S., Al-Khalil, M., & Al-Hazmi, M. (1995). Causes of Delay in Large Building Construction Projects. *Journal of Management in Engineering*, 11(2), 45-50.
10. Bharath, J., & Pai, S. (2013). Analysis of Critical Causes of Delays in Indian Infrastructure Projects. *International Journal of Innovative Research and Development*, 2((3)), 251-263.
11. Chan, D., & Kumaraswamy, M. (1997). A comparative study of causes of time overruns in Hong Kong construction projects. *International Journal of Project Management*, 15(1), 55-63.
12. Desai, M., & Bhatt, R. (2013). Critical Causes of Delay in Residential Construction Projects : Case Study of Central Gujarat Region of India. *International Journal of Engineering Trends and Technology (IJETT) - Volume 4 Issue 4, 4(April), 762-768.*
13. Doloi, H., Sawhney, A., Iyer, K., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, 30(4), 479-489.
14. Faridi, A., & El-Sayegh, S. (2006). Significant factors causing delay in the UAE construction industry. *Construction Management and Economics*, 24(11), 1167-1176.
15. Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study. *International Journal of Project Management*, 21(5), 321-326.
16. Iyer, K., & Jha, K. (2006). Critical Factors Affecting Schedule Performance: Evidence from Indian Construction Projects. *Journal of Construction Engineering and Management*, 132(8), 871-881.
17. Kaliba, C., Muya, M., & Mumba, K. (2009). Cost escalation and schedule delays in road construction projects in Zambia. *International Journal of Project Management*, 27(5), 522-531.
18. Koushki, P., Al-Rashid, K., & Kartam, N. (2005). Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics*, 23(3), 285-294.
19. Memon, A., Rahman, I., Akram, M., & Ali, N. (2014). Significant factors causing time overrun in construction projects of Peninsular Malaysia. *Modern Applied Science*, 8(4), 16-28.
20. Mezher, T., & Tawil, W. (1998). Causes of delays in the construction industry in Lebanon. *Engineering, Construction and Architectural Management*, 5(3), 252-260.
21. Ogunlana, S., Promkuntong, K., & Jearkjirm, V. (1996). Construction delays in a fast-growing economy: Comparing Thailand with other economies. *International Journal of Project Management*, 14(1), 37-45.
22. Sambasivan, M., & Soon, Y. (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*, 25(5), 517-526.
23. Singh, R. (2010). Delays and Cost Overruns in Infrastructure Projects : Extent , Causes and Remedies. *Economic and Political Weekly*, xlv(181), 43-54.
24. Vijayamohan Pillai, N., & K P, K. (2003). *Time And Cost Over-Runs Of The Power Projects In Kerala*. Trivandrum: Centre for Development Studies.