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Identification and Assessment of Critical Factors Causing Delays in Indian Metro-Rail Projects

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Abstract:

Construction delays are common in construction industry and create major concerns for project performance. Transportation infrastructure projects face delays in commissioning all over the world 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 using the relative importance index method. For this purpose, 47 different delay factors were identified, categorized into seven major groups,through detailed literature review and a case study. A detailed Questionnaire is prepared and survey has been conducted from Engineering professionals working/worked in Indian Metro-rail Projects. The relative importance of these delay factors were quantified by the relative importance index method. The ranking of the factors and groups were demonstrated according to their importance level on delay. According to the survey results, the factors and groups contributing the most to delays (those needing attention) were discussed, and some recommendations were made to minimize and control delays in commissioning of Indian Metro-rail projects.

Keywords: Metro-rail projects; India; Relative Importance Method; Schedule delay.

Introduction:

The urban population of India increased from 31.16% in 2011 to 34.9% in 2020 and it is projected to rise to 60 % by the year 2050.The trend shows an increase of urban population by 3.74% in the last decade. To respond this shift, The Government of India has launched 13 Metrorail projects in different cities. And also, it has been proposed to construct four more new metro rail projects to complete before the year 2024 with an objective to build a world class infrastructure facility in the country. Regardless of their requirements and importance, project time delay becomes a common phenomenon. As per the Ministry of statistics and program implementation Flash report (March -2019) it has been observed that 27% of Central sector projects are delayed beyond their scheduled date of completion. Further it states that around 10% of every dollar is wasted due to poor project performances. 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 analyzed 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) analyzed 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 Experience the delay. In the study, projects spread across the seventeen sectors of infrastructure as categorized 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 Metro-Rail projects in the last decade include Namma Metro, Rapid Metro, Mumbai Metro, Jaipur Metro, Chennai Metro, Kochi Metro, Lucknow Metro, Hyderabad Metro, Noida Metro, Ahmedabad Metro and Nagpur Metro. Almost all of these metro rail projects have faced delays.

Literature Review:

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&Jearkjirm (1996) observed significant delays in Thailand whereas Al-Momani (2000) conducted an investigation of severe construction delays in Jordan.
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.
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.

Research Methodology:

The research methodology can be summarized as follows: 47 different delay factors were identified and

categorized into 7 major groupsthrough a detailed literature review and delay analysis of a case study project. A questionnaire was developed to assess the perceptions of those in the Indian metro-rail construction industry on the relative importance of causes of delays. Then the questionnaire was filled out by 98 highly experienced construction professionals including project managers, site managers, managers, engineers, procurement managers, and technical consultants. The collected data were analyzed through the RII method. The analysis included ranking the different causes according to the relative importance indices. The analysis revealed the factors and groups that contribute most to delays. Then recommendations have been given to mitigate the delay factors identified.

Case Study:

The case study Project discussed is Construction of Elevated Viaduct from Ch 2900.000 to Ch 6151.000m (3250m approximate) for standard gauge twin track metro rail and three Elevated stations – Tondiarpet, Tollgate and Thangal, architectural, plumbing, roofing, signage, including design of temporary works (scaffolding, staging etc.,) traffic diversion, utility shifting and all associated works excluding piles and pile caps from Ch 3320.000 to Ch 5308.435m. The Contract period of the project is 01-11-2017 to 24-04-2019(450days) and the total value of the project is 314 Crores. key dates are the milestones of the project specified in the contract agreement. If the key-dates are not achieved correctly, it is called as delay and penalty is imposed to the contractor. From the start of the contract period to December 2018, all the data with planned dates and achieved dates and reasons for delay has been have been collected. For knowing the actual ground level information,from December 2018 to February 2019, all the delay reasons with planned dates from Baseline schedule and actual completed dates at ground level has been identified and noted. The project was running behind the schedule of 11months. The main factors obtained from the case study are Lack of labors, shoot-up in labor costs, Poor Project supervision, Rework due to errors, Violating site safety rules, Delay in sub-contractors work (high precision works and poor co-ordination), Poor co-ordination of Public around the area, Poor allocation of resources, Design Changes, Poor soil Conditions, Rainfall, Shifting of utilities and contingency works(sewage line, electric lines, Metro water lines; etc.), Narrow workspace.

Delay Factors:

From the detailed literature review and the case study project, 47 delay factors have been shortlisted under 7 groups. The delay factors are 1. Client Contributed factors are a. Delay in payments, b. Delay in land Acquisition and site handover to the contractor, c. Scope Change, d. Delay in obtaining permits from the local body, e. Delay in design Approvals and decision-making, f. Delays due to disputes between owners and co-owners, g. Delay in performing final inspection and certification by a third-party, h. Delays occurred in compliance of regulations and statutory approvals. 2. Contractor Contributed factors are a. Difficulties in financing project/company insolvency, b. Rework due to errors, c. Conflicts with other stake-holders, d. Lack of planning and scheduling from the contractor, e. Negotiations/time lapse for the award of work, f. Inadequate management and supervision, g. Unavailability of land for the casting of prefabricated structures, h. Delay due to safety issues, i. Delays due to sub-contractor's work. 3. Consultant Contributed factors are a. Repeated revision of drawings and inputs, b. Delay in approving overall designs and shop drawing, c. Delay in performing site inspection and testing of material samples, d. Lack of data collection and survey before design, e. Delays in producing & issuing design documents. 4. Labor Contributed factors are a. Shortage of labors, b. Lack of skilled labors for high precision works, c. High labor wages insist to hire a low number of labors, d. Unavailability of space for labor facilities and labor safety & health facilities. 5. Material contributed factors are a. Shortage of construction materials in market, b. Delay in material delivery, c. Transport issues in congestion hours, d. Quality of procured material/reordering, e. Lack of adequate space for storing materials on site, f. Price/ fluctuation in material prices, g. Theft of materials at site. 6. Equipment/Technology related factors are a. Unanticipated equipment breakdown & their idle time, b. Low productivity and efficiency of equipment, c. Use of obsolete construction technology, d. Availability of specialized equipment (launching girder, Tunnel Boring Machine, etc.), e. Lack of expertise to operate specialized equipment. 7. External factors are a. Effects of unforeseen subsurface & changing ground condition, weather, climate and rain effects on construction activities, b. Heavy traffic & overcrowding, c. Accidents during construction, d. Changes in government regulations & laws, e. Civil unrest/public strikes/elections, f. Economic crisis, g. Poor rates due to aggressive

competition at tender stage, h. Shifting of utilities & contingency works, i. Lack of communication & coordination among stakeholders.

Sample Size:

There are two types of Sampling namely Probability sampling, Non-probability Sampling. Probability Sampling is used in quantitative research and Non-Probability Sampling is used in qualitative research. Hence our study is a quantitative research, Probability Sampling technique is used to calculate the minimum number of sample size needed for analysis. In probability Sampling, Simple random Sampling is used. The total engineering professionals working in Indian Metro-rail projects were considered as a Total Population size and the minimum sample size is calculated.

Minimum sample size needed for analysis= $\frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$

N Population Size=10,000(Approx.)

e Margin of Error (as a decimal=0.1)

z Confidence Level (95%) (as a z-score=1.96)

p Percentage Value=0.5

Hence the minimum number of sample size needed for analysis is =95.126406≈96.

Questionnaire:

A questionnaire is 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 is 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 5-point Likert scale. (1. Very low occurrence, 2. Low Occurrence, 3. Medium Occurrence, 4. High Occurrence, 5. Very High Occurrence). The input corresponding to the frequency of occurrence of all the 47 shortlisted factors was asked. The professionals with experience on metro-rail 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.Snowball sampling, under the category of non-probabilistic sampling techniques, was used to gather responses for the study.

Cronbach's Alpha Reliability analysis:

Cronbach's Alpha Reliability analysis is a measure of reliability, internal consistency of the data. It has been carried out on the data collected to check the reliability of the data using IBM SPSS-Statistical Package for social sciences. The range of Cronbach's value is $0.9 \leq \alpha$ = Excellent,$0.8 \leq \alpha < 0.9$ = Good, $0.7 \leq \alpha < 0.8$ = Acceptable, $0.6 \leq \alpha < 0.7$ = Questionable, $0.5 \leq \alpha < 0.6$ = Poor, $\alpha < 0.5$ = Unacceptable. Thus, Cronbach's alpha value=0.939 obtained is greater than 0.9 indicates the Excellent consistency of the data.

Relative Importance Index 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 and methodology. 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:

Relative Importance Index(RII)=$\frac{\sum W}{A \times N}$

W Weightage for each factor by respondent (ranging from 1 to 5)

A Maximum Weightage (i.e. 5 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.

The relative importance index of each factor causing delays and their rank of each factor has been shown detail in Table .1.

Table 1:Responded Scores, RII and Ranking of Each Delay Factors,

Number	Factors causing delays	Respondent scores					RII	Rank
		1.Very low Occurren	2.Low Occurren ce	3.Medium Occurrenc e	4.High Occurren ce	5.Very High Occurrence		

		ce						
I	**Client Contributed Factors**							
1	Delay in payments	18	29	37	9	5	0.506	43
2	Delay in land acquisition and site handover to the contractor.	2	3	46	36	11	0.704	2
3	Scope change	9	14	53	22	0	0.58	29
4	Delay in obtaining permits from the local body	5	20	35	38	0	0.616	18
5	Delays in design approvals and decision making	2	29	34	31	2	0.604	22
6	Delays due to disputes between owners/co-owners	30	12	28	25	3	0.516	41
7	Delay in performing final inspection and certification by a third party	10	28	43	11	6	0.549	38
8	Delays occurred in compliance of regulations and statutory approvals.	2	17	58	18	3	0.606	20
II	**Contractor Contributed Factors**							
1	Difficulties in financing project/company insolvency	6	30	33	21	8	0.59	27
2	Rework due to errors	16	19	31	29	3	0.567	32
3	Conflicts with other stakeholders	14	25	31	23	5	0.559	36
4	Lack of planning and scheduling from the contractor	2	24	16	41	15	0.688	3
5	Negotiations/time lapse for the award of work	7	19	43	26	3	0.598	25
6	Inadequate management and supervision	8	12	30	35	13	0.668	9

7	Unavailability of land for the casting of prefabricated structures	14	21	40	15	8	0.563	34
8	Delay due to safety issues	11	13	45	20	9	0.606	21
9	Delays due to sub-contractor's work.	0	14	39	39	6	0.676	8
III	**Consultant Contributed Factors**							
1	Repeated revision of drawings and inputs	10	14	40	25	9	0.618	17
2	Delay in approving overall designs and shop drawing	8	18	46	20	6	0.596	26
3	Delay in performing site inspection and testing of material samples	7	32	35	21	3	0.561	35
4	Lack of data collection and survey before design	14	24	31	18	11	0.576	30
5	Delays in producing & issuing design documents	3	36	24	27	8	0.602	23
IV	**Labor Contributed Factors**							
1	Shortage of labor	8	12	26	33	19	0.688	4
2	Lack of skilled labor for high precision works	3	16	20	30	29	0.735	1
3	High labor wages insist to hire a low number of labors	8	20	38	16	16	0.624	14
4	Unavailability of space for labor facilities and labor safety & health facilities	16	32	18	21	11	0.557	37
V	**Material Contributed Factors**							
1	Shortage of construction	16	38	25	14	5	0.506	44

	materials in market							
2	Delay in material delivery	8	13	48	21	8	0.616	19
3	Transport issues in congestion hours	5	26	18	37	12	0.651	13
4	Quality of procured material/reordering	13	32	30	18	5	0.539	39
5	Lack of adequate space for storing materials on site	14	34	12	30	8	0.567	33
6	Price/ fluctuation in material prices	9	34	37	18	0	0.531	40
7	Theft of materials at site	16	14	10	32	26	0.678	6
VI	**Equipment/Technology Related Factors**							
1	Unanticipated equipment breakdown & their idle time	3	14	35	33	13	0.68	5
2	Low productivity and efficiency of equipment	5	11	41	31	10	0.661	11
3	Use of obsolete construction technology	14	21	33	26	4	0.569	31
4	Availability of specialized equipment (launching girder, Tunnel Boring Machine, etc.)	10	21	26	31	10	0.62	16
5	Lack of expertise to operate specialized equipment	5	30	30	15	18	0.622	15
VII	**External Factors**							
1	Effects of unforeseen subsurface & changing ground condition, weather, climate and rain effects	12	28	23	24	11	0.588	28

	on construction activities							
2	Heavy traffic & overcrowding	0	25	28	32	13	0.667	10
3	Accidents during construction	22	27	29	14	6	0.508	42
4	Changes in government regulations & laws	24	27	28	16	3	0.492	46
5	Civil unrest/public strikes/elections	32	24	28	11	3	0.455	47
6	Economic crisis	19	34	27	15	3	0.496	45
7	Poor rates due to aggressive competition at tender stage	11	17	38	24	8	0.602	24
8	Shifting of utilities & contingency works	3	12	36	38	9	0.678	7
9	Lack of communication & coordination among stakeholders.	5	17	33	30	13	0.659	12

Result and Discussion:

To investigate the potential factors that causes delay in the Indian metro rail projects, critical delay factors have been grouped in to four RII ranges, and is shown in Fig.1 to Fig.4. From the above Table .1, the critical factors with the top fifteen ranks have been picked up and shown in Table .2 along with Relative Importance Index (RII) and Rank of each factor and the factor group with each factor belongs to.

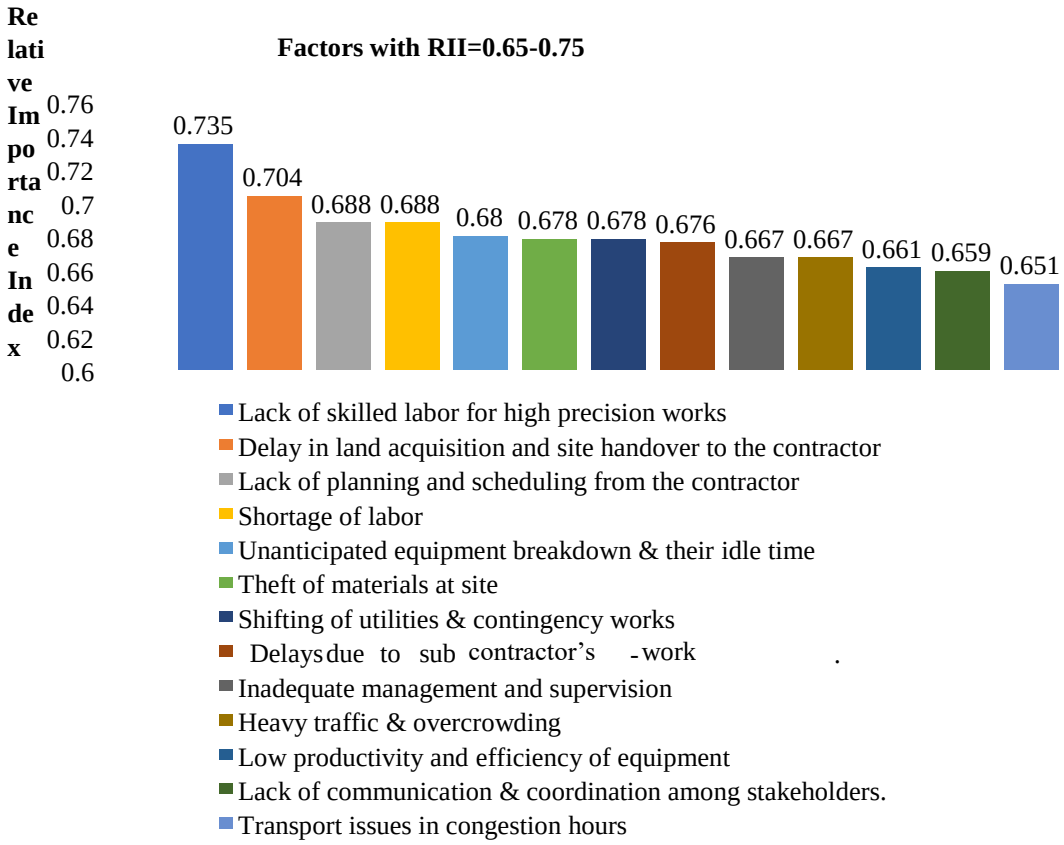

Fig 1. Relative Information Index between 0.65 to 0.75

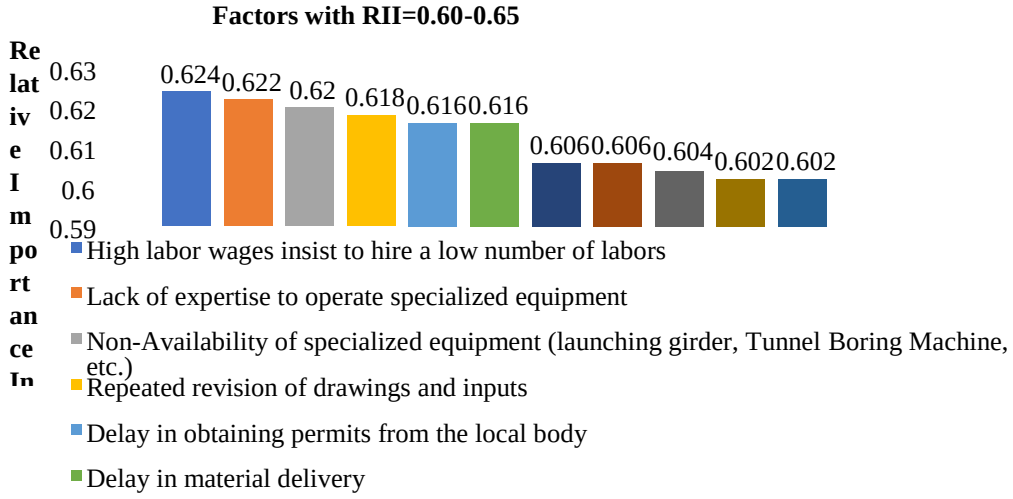

Fig.2 Relative Information Index between 0.60 to 0.65

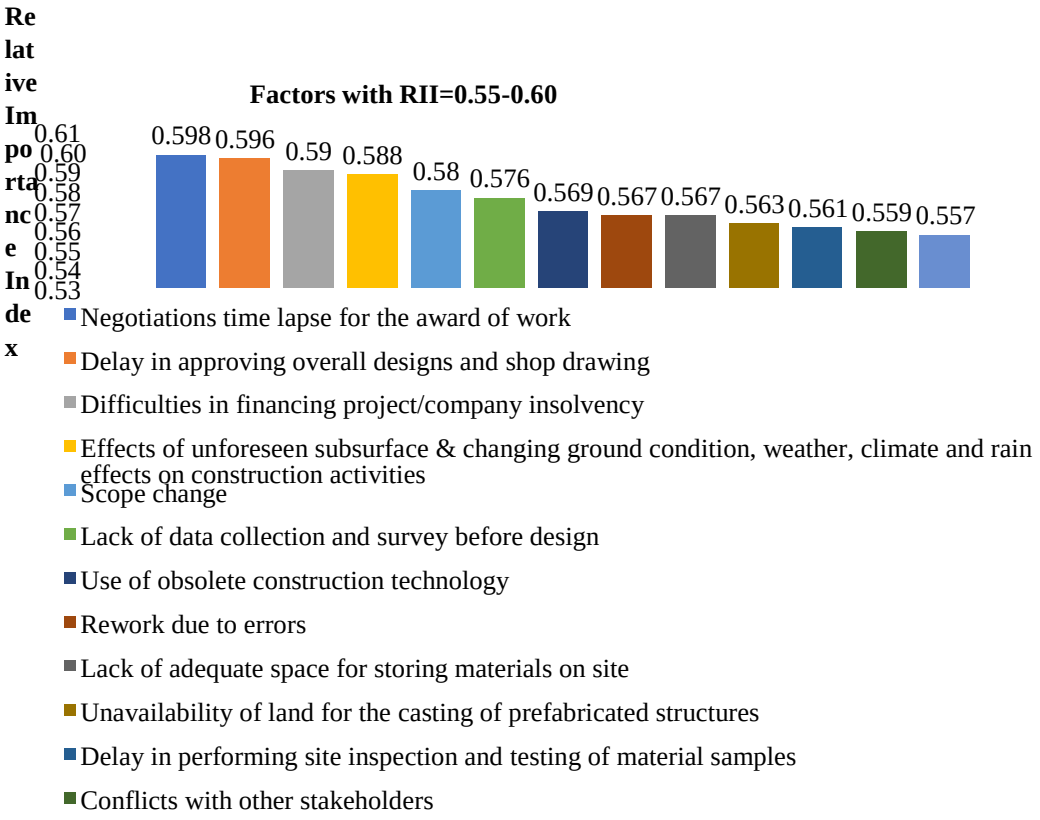

Fig 3. Relative Information Index between 0.55 to 0.60

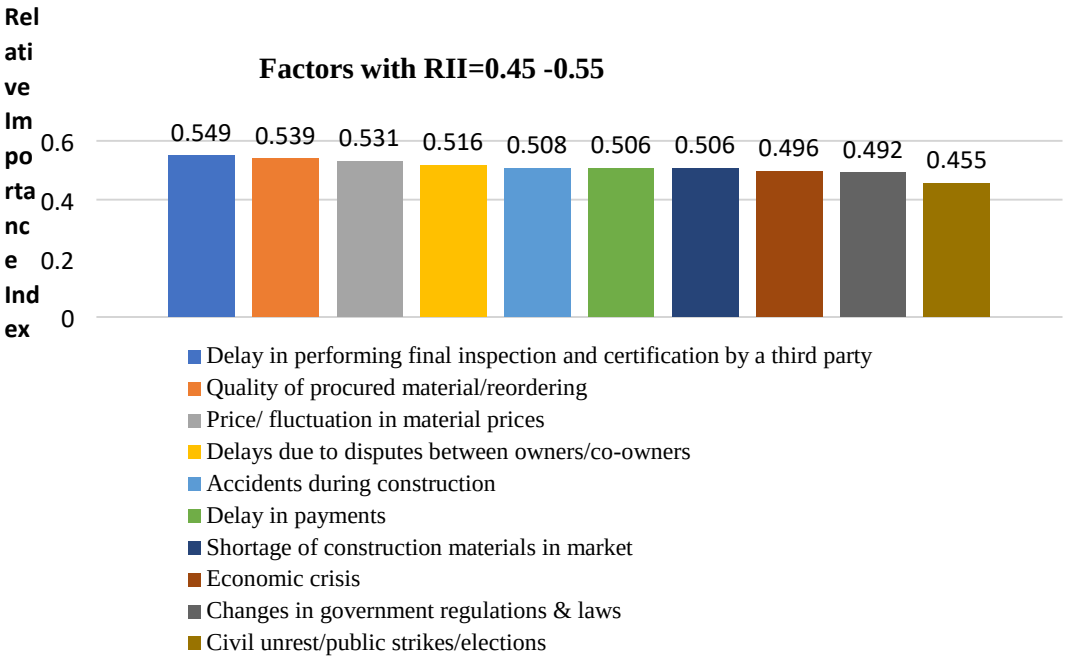

Fig 4. Relative Information Index between 0.45 to 0.55

Table 2: Top 15 Critical Factors

Factors	Factor Group	RII	Rank
Lack of skilled labor for high precision works	Labor Contributed	0.735	1
Delay in land acquisition and site handover to the contractor	Client Contributed	0.704	2
Lack of planning and scheduling from the contractor	Contractor Contributed	0.688	3
Shortage of labor	Labor Contributed	0.688	4
Unanticipated equipment breakdown & their idle time	Equipment/Technology Related	0.680	5
Theft of materials at site	Material Contributed	0.678	6
Shifting of utilities & contingency works	External	0.678	7
Delays due to sub-contractor's work.	Contractor Contributed	0.676	8
Inadequate management and supervision	Contractor Contributed	0.667	9
Heavy traffic & overcrowding	External	0.667	10
Low productivity and efficiency of equipment	Equipment/Technology Related	0.661	11
Lack of communication & coordination among stakeholders.	External	0.659	12
Transport issues in congestion hours	Material Contributed	0.651	13
High labor wages insist to hire a low number of labors	Labor Contributed	0.625	14
Lack of expertise to operate specialized equipment	Equipment/Technology Related	0.623	15

Ranking of Factor Group:

The seven Factor Group has been ranked using RII. Table 3 summarizes the RII and ranking of Factor group of delay. Labor contributed factors are ranked first in the list of seven categories with an overall RII score of 0.651 as shown in the Table 3. This is because the factors like lack of skilled labors for high precision works, shortage of labors influence more in schedule overruns. The second Group identified is Equipment Contributed Factors because Unanticipated equipment breakdown and their ideal time, low productivity and efficiency of equipment causes the equipment/methodology related factors to be ranked second. Lack of planning and scheduling from the contractor, delays due to sub-contractor's work, Inadequate management and supervision make contractor contributed factors to be ranked third. The other categories have less than 0.6 values of RII and have comparatively less influence on schedule overruns. These categories include consultant contributed factors, client contributed factors, Material contributed factors and External factors.Fig.5. shows the Ranking of Factor Group based on RII.

Table 3: Ranking of Factor Group

Factor Group	RII	Rank
Labour Contributed Factors	0.651	1
Equipment/MethodologyRelated Factors	0.631	2
Contractor Contributed Factors	0.613	3
Consultant Contributed Factors	0.591	4
Client Contributed Factors	0.585	5
Material Contributed Factors	0.584	6
External Factors	0.572	7

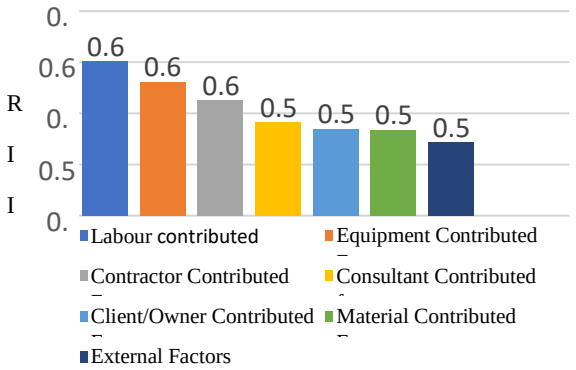

Fig.5. Ranking of Factor Group based on RII

The above factors can be further classified into:
Human related factors = 5/7 = 71.43%
Machineries/ Technology related factors = 1/7 = 14.29%
External factors = 1/7 = 14.29%
These percentage combinations show very clearly that human related factors are causing more delays than the Technology and the External factors.

Discussion of Results:

The ten most critical factors of delays as shown in Table 2 is presented in Fig.6: are 1. Lack of skilled labor for high precision works, 2. Delay in land acquisition and site handover to the contractor, 3. Lack of planning and scheduling from the contractor, 4. Shortage of labor, 5. Unanticipated equipment breakdown & their idle time, 6. Theft of materials at site, 7. Shifting of utilities & contingency works, 8. Delays due to sub-contractor's work, 9. Inadequate management and supervision, 10. Heavy traffic & overcrowding.

Table 4. and Fig.7 Shows The top ten Minimum Critical Factors, does not contribute much to the delays in commissioning of metro-rail projects but have a very little impact on delay of the projects. Corresponding Range of relative information Impact factor value lies between 0.45 to 0.55

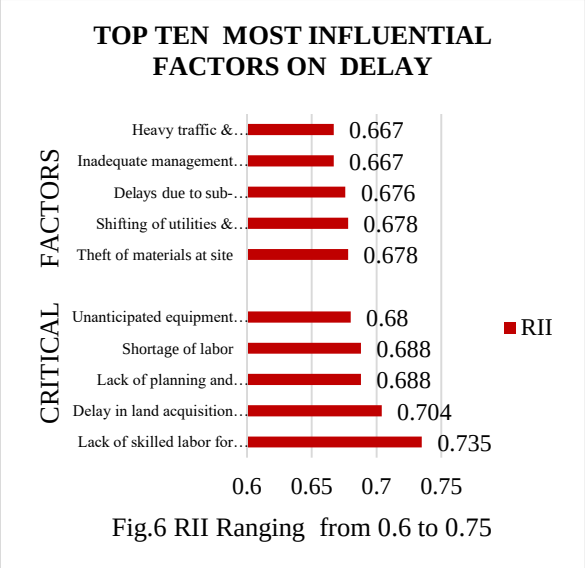

Fig.6 RII Ranging from 0.6 to 0.75

Table 4: Minimum Critical Factors

Factors	RII	Rank
Civil unrest/public strikes/elections	0.455	47
Changes in government regulations & laws	0.492	46
Economic crisis	0.496	45
Shortage of construction materials in market	0.506	44
Delay in payments	0.506	43
Accidents during construction	0.508	42
Delays due to disputes between owners/co-owners	0.516	41
Price/ fluctuation in material prices	0.530	40
Quality of procured material/reordering	0.539	39
Delay in performing final inspection and certification by a third party	0.549	38

This section discusses the details of the critical factors of delay in metro rail projects.

1. Lack of skilled labors for high precision works: Skilled labors are trained for particular work like crane operation, launching girder operation, Tunnel Boring machine operation, reinforcement tying, bar bending, carpenting works etc. they are in huge demand. As number of unskilled labors itself is in shortage, finding unskilled and training them is too difficult. If we train also, making them retain is very difficult.

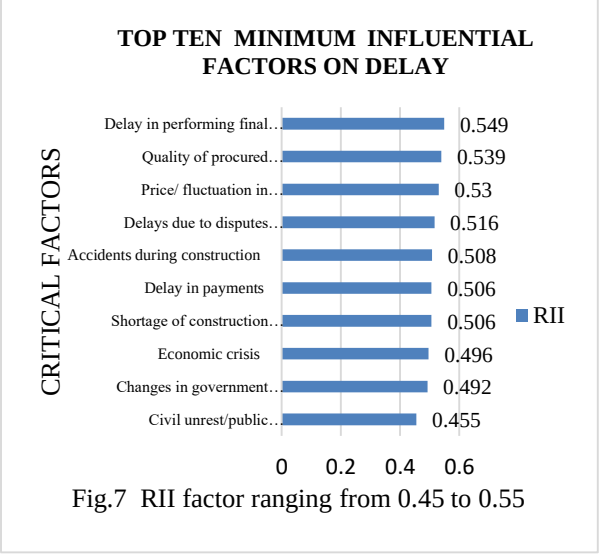

Fig.7 RII factor ranging from 0.45 to 0.55

2. Delay in land acquisition and site handover to the 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, Hyderabad, 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 have caused delays.

3. Lack of planning and scheduling from the contractor: Planning and scheduling is the important process in keeping the projects in control. But most of the contractors, doesn't have effective planning team. Usually, in most of the projects the plans given by planning team is not executed properly and poor co-ordination from the execution engineers for the plans of planning team.

4. Shortage of labor:Construction of projects is frequently struck by shortage of 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 which is discussed in the first factor.

5. Unanticipated equipment breakdown & their idle time: Poorresourcemanagement so that equipment is not assigned properly to the desired works at the right time. Poor resource planning from the planning team also causes great delays. Hence the idle time is more hence breakdown also happens.

6. Theft of materials at site: As theMetro-Rail projects happens in heart of the city. There will be shortage of space to store materials at site and taking advantage of the space constraint anti-social people loot the materials at night and when needed to work the material will be missing, hence the materials have to be re-ordered and delay occurs.

7. Shifting of utilities & 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. The local bodies don't have exact data of where the utilities are and make the finding of utilities difficult and results in delay. These utilities may include underground water supply lines, waste water lines, sewage network, electricity cables, OFC (Optical Fibre Cable) line, etc.

8. Delays due to sub-contractor's work: To complete the projects quickly and resource un-availability from contractor, it is necessary to outsource the works to sub-contractors. Hence, sub-contractors take up the work. Due to poor co-ordination from the sub-contractors it results in delay of the project.

9. Inadequate management and supervision: The supervision and management at site is very poor so that the available labors are kept idle. Hence the works are not completed at site.

10. Heavy traffic & overcrowding: As metro-rail projects happens in heavily congested areas, the transportation of materials, the movement of machineries around the site, the fear of safety to public around the area by the works make the critical works like erection to be carried out at night, hence the works get delay by these heavy traffic and overcrowding.

Recommendations:

The following recommendations have been given to the top 10 critical factors causing delays in Indian Metro-rail projects.

1. Lack of skilled labors for high precision works: Automation should be adopted to decrease the number of skilled workers needed to complete the work. Training more workers to get skilled and retaining them till project completion using legal bonds.

2. Delay in land acquisition and site handover to the contractor: The land should be kept ready before starting of the project. The land acquisition plan for large infrastructure projects should be included in master plan and proper things have to be arranged before.

3. Lack of planning and scheduling from the contractor: The planning team should address this issue effectively. The execution team should properly co-ordinate with the planning team with day to day targets and co-ordinate with them. The latest planning techniques like last planner system can be

adopted to increase the efficiency of the schedules prepared and complete the work in time.

4. Shortage of labor: The salaries of the labor force should be increased by attractive salary, shelter and benefits should be given to them and make them retain. If required they could be hire from various parts of India, and neighbouring countries like Nepal, Bhutan, Bangladesh. Wherever possible to ease the work of the labors automation can be introduced.

5. Unanticipated equipment breakdown & their idle time: Equipment related breakdown can be rectified by proper maintenance. The idle time of the equipment can be rectified by proper resource allocation. Proper co-ordination should be maintained between different teams to reduce the idle time of the equipment.

6. Theft of materials at site: Theft of materials not only cause huge delays but also huge cost overruns. The current situation has watchmen to look after the sites. Increasing the count of watchmen and installation of CCTV cameras at site for monitoring can considerably reduce the theft and proper legal actions have to be taken for law-breakers.

7. Shifting of utilities & contingency works: The data available for utility locations are very less and are in-accurate. Proper data about the location of the utilities should be made using GIS (Geographical Information Systems). The Shifting of utilities should be planned before starting of the project.

8. Delays due to sub-contractor's work: Proper sub-Contract management should be maintained. The sub-contract agreementshould include penalty as like the main contract norms.

9. Inadequate management and supervision: Proper Co-ordination should be maintained between the site engineers, supervisors, labors and managers to facilitate proper communication. Implementation of BIM(Building Information Modelling) can decrease the communication gap between the professionals.

10. Heavy traffic & overcrowding: This seems to be a great problem. Controlling the traffic and overcrowding is almost impossible, even though if proper traffic diversion plans are made. Hence, Plan the high risk works at night and properly utilize the resources to achieve maximum productivity.

The top ten minimum critical factors along with the respective Relative Importance Index (RII) and Rank has been shown in Table 8.3. These Minimum critical Factors does not contribute much to the delays in commissioning of metro-rail projects but have a very little impact on the delay of the projects

Conclusion:

The Analysis, findings and Recommendation in this present study has been concluded from data collected through questionnaire survey with concerned stack holders engaged in the metro rail project and the results are validated through descriptive statics. Finding from the recommendations sections highlights the human related factors contributes to 71.49%, Machineries/Technology Related factors contributes to 14.29%, and the external factors contributes to 14.29%. Labor, Equipment/Technology and external related factors were found to be the major categories responsible for the delay in Indian Metro Rail Projects.

The recommendations sections also highlight from real time investigation have been given to mitigate the current delays in the metro rail projects are like, Theft of materials at site, Unanticipated equipment breakdown & their idle time. The present study underline to highlight yet another factor found during the course of investigation is lack of personal interest and more of Lethargic Mind set in all levels which make them each other for delays. More personal involvement is needed for Success of the projects.

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