



“IDENTIFICATION OF THE FACTORS CAUSING OBSTACLES AND THEIR EFFECTS ON CONSTRUCTION PROJECTS (A CASE STUDY OF PUNE METRO)”

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Abstract: In order to meet rapidly changing demand speedy construction projects has become prime most important. It's highly impossible to manage the project through the conventional techniques. It has been observed many times that the productivity of the construction depleting and leads to rework and produces unnecessary wastages such as over production, inventory, unnecessary transportation, workers displacements, over processing, defect, waiting of materials, unused employee creativity, work accident, etc. Therefore, practical ideas and techniques need to be used in construction that will help projects teams to deal with delays in construction with the use of optimum resources, planning, management and this can be achieved by using an construction principles and techniques. So, this paper aims to overview and discuss the applicability of principles and its techniques used in construction project which helps to reduce time & cost in construction and brings the quality of work in product developing process with raising the profit level and also which factors affects to adopt management in construction has discussed with the current construction practices and past studies In India. The implementation of management in construction industry is a major task also it very subjective depending on kind to project being done. Due to lack of attention and illiteracy towards the management principle the owner, contractor, engineers, act of God etc. are still developing stage to implement this principle in their project. This paper mainly focuses on to identify the possibilities of implementation of lean management in construction industry. It will be derived by preparing the questionnaire and conducting the interview with the project personals like client, engineers and contractor's representative etc. The questionnaires were evaluated to adopt the methods through statistical techniques. This paper presents the possibilities of effective utilization of management principle in construction industry, which can surely increase the quality of work and profit rate by eliminating the cost & time of completion of the project.

Metro projects as part of Mass rapid transit system are vital to achieve sustainable and livable cities along with meeting demand of population growth. Almost all Indian metro projects are delayed. Delay is the most common, complex, and dangerous problem in construction. Most construction projects in developing countries running delay. Regardless of size or complexity, deadlines and unpredictability abound. This study reviews prior research on time and cost overrun drivers.

Keywords- Delay, Metro, Cost, Time, budget, Management, factors

I. INTRODUCTION

Impacts of COVID-19 on Indian economy is enormous and has brought down GDP of India from 8.2 to 3% in 2019 and post COVID effects still being felt. Construction industry being labour intensive and core and important industry is no exception to impact of COVID. Construction sector COVID-19 victims are becoming more numerous and dynamic by the day, which is having an influence on the **Metro Projects**. Government lockdowns are disrupted the supply chain; labour shortages are emerging; companies are experiencing an economic downturn and they are having difficulty keeping their contracts also.

Management of the supply chain: In several places of the world, the supply chain has been interrupted in various ways. Various construction materials are necessary, but they are not reaching the construction site from outside due to COVID-19 lockdown, which has caused delays in the construction process. Various resources for construction work that come from various industries in the country or overseas via various vehicles, those items cannot come. Because all cargos are unable to reach target site, the essential materials are unable to arrive, and the work is halted. It has not only caused the construction sector to shut down, but it has also harmed the livelihoods of those who transport these materials in cargos, labours as well as the factories that produce these products, which are losing a lot of money because they are not being sold.

An issue with transportation: All modes of mobility in the country have been hampered as a result of the nationwide lockdown. As a result, no materials are being delivered to the construction industry, and no workers are able to work from home. As a result, the work has come to a halt for a long period.

Labor scarcity: To begin with, workers are unable to get to work since the transit system is entirely shut down. Second, because the sickness is caused by a viral infection, workers who come into touch with one another are more likely to spread it. As a result, many workers refuse to come to work. Furthermore, forcing workers to labour without any protection is impossible.

Financial difficulty: Companies are not making any profit as a result of the work stoppage; on the contrary, more losses are being incurred, and not only the company is losing money, but all of the suppliers who provide the required materials to various companies for use in the construction sector are also losing a lot of money. Since the company's shutdown, the supply chain has been disrupted, and factories that create goods have ceased operations, resulting in several job losses. Furthermore, the government is unable to collect adequate taxes from all of these sites due to the non-sale of factory-produced goods and the shutdown of the building sector, which has a direct influence on the country's GDP, which impacts the global economy.

Issues with contractual implication: It is primarily based on the 'force major' clause. This clause has a number of rules, one of which is 'Large Scale Epidemic.' This category includes the COVID-19 pandemic. Different contractors placed their various tools in various locations for usage in various machinery construction sectors, but because to the lockdown, all of these equipment have been laying around for a long period. Companies have contracts with contractors to work with all of this equipment for a fee, and if the contract includes a 'Force Majeure' clause, the contractor will not be compensated by the agency if the project is delayed. When contractors stop working, the effect is a significant financial loss.

Unemployment: Because of the lockdown, businesses are losing a lot of money. As a result, businesses are unable to appropriately compensate their employees, and many people are laid off. Many people's jobs have been taken away as a result of this. Their families are also dealing with a lot of difficulties as a result of their job loss. Overall, a concerning scenario has developed in India, Projects have been considered as temporary based production systems which need to be designed, planned, produced and delivered within a specified time. Fast track projects with long, complicated supply chains involving many players and subject to multiple, extensive process design changes have complex flow management that has failed miserably. As a result, the industry is distinguished by delays and often has suffered cost and time overburdens. In general, a very high level of hopeless activities is confirmed to exist in the construction industry. Several studies have confirmed that, wastes in construction industry represent a relatively large percentage of production cost. The existences of significant number of abortive in the construction have decrease the overall performance and productivity of the industry, and certain serious measures have to be taken to rectify the current situation. It has been contended by the Construction Institute that about 57% of productive time waste can be found in the construction industry.

Present scenario of construction: It has become crucial to seek innovative and creative solutions/alternatives that ensure better and more optimized management techniques that could minimize the sources of wastes and increase the performance of the construction process. The construction industry encountering different problems as a result of the uncertainties of the global economic climate, environmental hazards, including labor delayed projects and zero margin contract bids, greenhouse gas emissions etc. So, there is need for waste minimization and improvement of productivity in construction activity. Productivity is critical determinant of cost efficiency. The conventional method of construction is not renewable. In one of the researches it is estimated that current system of construction had around 50% of hopeless efforts. Most of the present construction practices run with traditional work flow methods and uses conceptual models of construction management because there are some barriers to adopt lean management in present construction practices those are mentioned further.

Alignment Issue:

Initial plans were to build a few sections underground and the rest elevated. However, citizens of Pune did not want elevated routes as they felt that the roads could not bear the increased traffic that would result from the construction. Most roads were too narrow to accommodate the pillars of elevated routes. It was decided that all the routes in the city would be underground, although the map and the details of phases showed elevated routes. In November 2011, the Maharashtra Government declared that all the routes would be underground. However, in April 2012, the PMC declared that all routes will be as per the DMRC report, mostly elevated and partially underground in core city areas. On May 27, 2015 the then Union Urban Development Minister M Venkaiah Naidu stated that underground metro was not a feasible option and that Pune, like other cities, will have to get an elevated metro as suggested by the DMRC.

But as per the city activists, elevated metro is not possible due to presence of some flyovers along the route of metro and narrow roads on the metro corridor, which will cause traffic congestion and interruption. In order to clarify this confusion, Maharashtra Chief Minister Devendra Fadnavis announced that Pune will get "mixed-metro", as the alignment of some routes does support elevated sections.

Current development about infrastructure projects in India: Infrastructure sector is a key driver for the Indian economy. The sector is highly answerable for propelling India's overall development and enjoys intense focus from Government for initiating policies that would ensure time-bound creation of world class infrastructure in the country. Infrastructure sector includes power, bridges, dams, roads, and urban infrastructure development.

Market Size: According to the Department for Promotion of Industry and Internal Trade (DPIIT), FDIs in the construction development sector (townships, housing, built up infrastructure and construction development projects) and construction (infrastructure) activities stood at US\$ 26.14 billion and US\$ 25.38 billion, respectively, between April 2000 and June 2021. In FY21, infrastructure activities accounted for 13% share of the total FDI inflows of US\$ 81.72 billion.

Today, integrating both tangible and intangible variables into the construction of an image, the development of public transit such as metro “merges function with form, becoming the intersection of mass mobility and mass/ popular culture”. Several studies have demonstrated that the promotion of metro projects has relied on narratives that revolve around the efficient movement of people.

Therefore, metro, as a form of urban transport, has become both a metaphor and a catalyst for achieving:

The tangible goals of congestion reduction, environmental amelioration and increased safety and ii) the intangible objective of social and cultural transformation. Viewed in it's entirety, the metro forms a vital piece of transport infrastructure, symbolizing the transformation of the city into a modern metropolis.

Aim:

“To identify the root causes for obstacles in progress of construction of Pune Metro Projects and identify their effects in perspective of time and cost”

1.1 Objectives:

1. To Study Planning and scheduling of Pune Metro Projects.
2. To compare metro construction plans and timing to actual progress.
3. To identify the fundamental causes of construction delays in Pune Metro Projects by using Delphi methodology, relative importance index and questionnaires survey.
4. To find solution to overcome delays with advance construction technology.

II. LITERATURE REVIEW

There are lots of 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. By going through these scientific papers and other theoretical literature which are related to the project studied in this thesis, written about how to identify, evaluate, analysis and manage risk within Metro construction. This study takes reference of the above-mentioned category of works to derive a methodology for research.

2.1 Nina Ryd,” Construction Clients Challenges - Emphasizing Early Stages”, ScienceDirect Procedia - Social and Behavioral Sciences 119 (2014) 134 – 141. The built environment industry faces various problems such as urbanization, energy efficiency, climate change, and population shifts. Also, unknown future obstacles. Authors claim that accomplishing objectives - and creating sustainable, appealing cities and regions - requires architects, engineers, and urban planners knowledge. Many actors are involved in a sustainable built environment, including professionals, policymakers, and concerned parties.

Part 3 introduces new explanatory models. Although the importance of long-term and sustainable urban development is widely acknowledged, it has yet to be represented in the procedures and patterns of organization for project implementation and administration. [2]

2.2 Muhammad Ali Musarat, Wesam Salah Alaloul,” M.S. Liew Impact of inflation rate on construction projects budget: A review Published by Elsevier B.V. on behalf of Faculty of Engineering, Ain Shams University. This article examines how inflation affects the economy and the building sector. The authors observed that most construction projects' economics and budgeting ignore inflation, causing cost overruns due to annual changes in building materials, labor costs, and machinery hire rates. Also, a paradigm has been presented that emphasizes the close correlation between inflation and the building industry. The methodology can help future budget estimation models avoid inflation-related project cost overruns. [3]

2.3 Yash Kumar Mittal, Virendra Kumar Paul,” Identification of critical factors for delay in metro rail projects in India (2018) This Study identified the critical factors for delay in metro rail project in India. They identified 10 most critical delay-factors; . The identified factors included: Delay in land acquisition and site handover to contractor, Shifting of utilities and contingency works, Scope change, Delay in payments, Effects of unforeseen subsurface and changing ground condition, (Shortage of construction materials in the market, Delays in design approvals and decision making, Shortage of labour, Lack of data collection and survey before design, and Delay in obtaining permits from local body.. The Application of suitable course correction measures targeting the critical factors can result in mitigation of delays.[4]

2.4 Renata Stasiak-Betlejewska , Marek Potkány,” Construction Costs Analysis And Its Importance To The Economy”, Science Direct Procedia Economics and Finance 34 (2015) 35 – 42.The study mix of elements determining its energy efficiency is: architectural form, structure, function, utility, material type and location. The key features of building a house that do not greatly increase investment prices, but have a large influence on lowering energy use, which generates national energy policy. [5]

2.5 Ravi Bhutania, Dr.Sewa Ram Dr. Kayitha Ravinder ,” Impact of metro rail construction work zone on traffic environment ScienceDirect, Transportation Research Procedia 17 (2016) 586 – 595. According to the author, the influence of metro rail construction work zones on traffic is quantified. An economic loss of this magnitude necessitates comprehensive work zone scheduling and traffic control approaches. To mitigate the effects of work zones, systematic scheduling and traffic control measures must be employed. Shockwaves can be reduced by adjusting traffic signal timings. Since bus passengers in work zones lose the most time, public transportation should be prioritized in work zones. One of the traffic control strategies in work zones is to restrict certain vehicle types during peak hours. [6]

2.6 Saurav Dixit,” a study of enabling factors affecting construction productivity: Indian scenario”, International Journal of Civil Engineering and Technology Volume 8, Issue 6, June 2017, pp. 741–758, Article ID: IJCIET_08_06_080. Using a relative relevance score, this research finds the top 10 factors influencing construction productivity. The top three are decision making, planning and logistics. Second, using factor analysis/principal component analysis, 7 components were generated from 24 traits, explaining 74.58 percent of the variance. Unskilled workers and inefficient site management are the main causes of poor site coordination. [7]

2.7 Mohd Danish, Dr. Syed Khursheed Ahmad, "Delay In Construction Project", IJARIE-ISSN (O)-2395-4396 Vol-5 Issue-4 2019 Among the top five reasons for delays in India building projects are low bidder selection, incorrect bid pricing, and insufficient cash flow (financial difficulties). Late payments (according to progress), non-availability of required equipment or late availability, the type of tenders in which the selection process to negotiate lower prices or other criteria more labor, design changes, and unintentional (or intentional) implementation errors that require readjusting. The high number of delayed projects harms the community. Lack of revenue and production. [8]

2.8 Surabattuni Murali, Sanjeet Kumar, "Factors Affecting Overruns Construction Time and Cost: A Case Study" International Journal of Recent Technology and Engineering. This paper investigates the primary reasons of time and expense overruns in construction projects using a survey of workers in the Shan-E Awadh project for ground anchoring. These include material management, site conditions, unskilled labor/labour strikes, contractor financial issues, and machine and equipment issues. The above five factors have the highest precision of all 81 factors. Other factors influenced schedule delays and cost overruns, but not as much as the preceding five. The results reveal that many problems in ground anchoring projects stem from the project execution; to overcome these overruns, project management strategies of planning, directing, regulating, and monitoring are required. [9]

2.9 Nagasai Karthik, "problems involved in various stages of construction of metro rail in india and the judicial view of the problems" International Journal of Civil Engineering and Technology Volume 9, Issue 4, April 2018, pp. 1284 1289. The paper concludes that most issues identified during metro construction are resolved using various resolution processes as stipulated in the construction requirements. This process takes more time and resources than other processes and the limit of higher appeal is quite high, so it is advised to resolve the issue within the concerned parties using other methods. A new structure has a new issue and no two constructions are same, therefore it is impossible to prevent issues, however strategies to handle them more efficiently are feasible. [10]

2.10 Berenice Bon, EHESS-CEIAS Paris, Project FP7 Chance, Sustain, France, a new megaproject model and a new funding model. Travelling concepts and local adaptations around the Delhi metro, by Berenice Bon, Habitat International 45 (2018) 223-230 The report presents a case study of the Delhi metro, which is a testing ground for a new funding mechanism for urban megaprojects that consists of financing part of the capital costs by capturing the land value, an instrument not previously used by public actors in India. [12]

2.11 Francesca Medda, UCL QASER Lab., University College London, Gower Street, London, United Kingdom, (2019) land value capture finance for transport accessibility: a review. Journal of Transport Geography 25 (2019) 154–161. This paper promotes accessibility as a public-private strategy for increasing urban value. Our reliance on autos must be reduced, as must their direct and indirect effects on urban mobility. For example, mass transit serves many commuters. Bus rapid transit (BRT) and light rail transit (LRT) are creative solutions to the urban accessibility problem, but they need large upfront investments. [13]

2.12 Guicai Li, Xiaofan Luan, Jiawen Yang and Xiongbin Lin, (2014) value capture beyond municipalities: transit-oriented development and inter-city passenger rail investment in china's Pearl River delta. Journal of Transport Geography 33 (2018) This article how net new jobs would be in cities, and supporting urban infrastructure would require \$1.2 trillion, nearly eight times what is currently invested in Indian cities. 30 billion ft² of paved roads (McKinsey Global Institute, 2010). That is what happens when cities lack good infrastructure and other requirements. But, due to limited budgets, cities are unable to meet the increased demand for infrastructure. Innovative infrastructure provisioning necessitates new. [14]

III. RESEARCH METHODOLOGY

3.1 Problem Statement

"Metro is one of the finest choices when transportation infrastructure grows fast in metro centers. However, construction progress often does not match real planning, causing time and expense loss. It is important to identify the root causes so that similar projects can be avoided".

3.2 Research Methodology

The Delphi technique (also referred to as Delphi procedure or process), is a method of congregating expert opinion through a series of iterative questionnaires, with a goal of coming to a group consensus. In fact, in 150 studies that used the Delphi technique, there was no universally agreed upon working definition of the technique. There are many variants used, some of which have departed widely from the original Delphi technique.

Since its development in the 1950's by the RAND Corporation, several refinements and modifications have been made, such as specific strategies for different fields, including business, government, and healthcare. There are four characteristic features of the Delphi technique that distinguish it from other group decision making processes. These are: anonymity, iteration with controlled feedback, statistical group response, and expert input.

So, a questionnaire was designed to compare 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 project. 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 ranking by various categories of respondents was analyzed by using Spearman's rank coefficient. The factors were based on 27 categories of delay as below:

1. Change in Scope
2. Delay in Land acquisition and site Handover to Contractor
3. Covid19 Pandemic
4. Obtaining permits from local bodies
5. Litigation and decision delays
6. Design approvals and decision making
7. Negotiations time lapse for award of work
8. Approving overall designs and shop drawing
9. Repeated revision of drawings and Inputs
10. Lack of data collection and survey before design
11. Delay in payments
12. Performing final inspection and certification by a third party
13. Difficulties in financing
14. Project/company insolvency
15. Shortage of Plant and Machineries
16. Unanticipated Equipment breakdown and their idle time
17. Conflicts with another stakeholder
18. Unavailability of Land for casting of prefabricated structures
19. Inadequate management and supervision
20. Performing site inspection & testing of material
21. Rework due to errors
22. Shortage of labour
23. Heavy traffic, over-crowd & other restrictions on site.
24. Shortage of construction materials (Like Steel, Cement, Aggregate)
25. Delay in material delivery especially while importing Material transport issues in congestion hours during day.
26. Contractor's Economic crisis
27. Social and cultural impacts

The professionals with experience on metro projects were considered as respondents for the questionnaire survey. The questionnaire was distributed to Managers, Engineers, directors, architects, structural consultants, service consultants, etc. A five-point Likert scale from 1 (no occurrence) to 5 (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 1 (no impact) to 5 (extreme impact). A pilot survey was conducted amongst professionals with work experience in metro 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. A sample format of questioner as below:

3.3 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

$$RII = \Sigma W / A * N$$

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

$$\Sigma W = 5 \times W_5 + 4 \times W_4 + 3 \times W_3 + 2 \times W_2 + 1 \times W_1$$

W₅ = Number of respondents for strongly Agree

W₄ = Number of respondents for Agree

W₃ = Number of respondents for not sure

W₂ = Number of respondents for Disagree

W₁ = Number of respondents for strongly Disagree

A = Maximum Weightage (1.e. 5 in this case)

N = Total Number of respondents (I. e. 57)

Higher value of Relative Importance Index (RII) specifies 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.

IV. DATA COLLECTION & ANALYSIS

4.1 Case Study

SPV of Government of India and Government of Maharashtra named Maharashtra metro rail corporation is set up for implementation of Pune metro project. The project intends to develop world class metro stations and surrounding areas featuring the rich cultural heritage. Modern, Safe, Secured, Comfortable and an integrated public transport system for the city of Pune and Pimpri Chinchwad will enhance the lifestyle of the citizens.

4.2 Cost:

The estimated project cost for Phase I and II are INR 69.6bn and INR 32.24bn respectively. The project cost will be funded by the PMC and PCMC together bearing 10% of this cost, the state government 20% and the central government will bear 20% of this cost. The remaining 50% will be obtained from loans. The state government's share of 20% includes the expenses of acquiring land, including government land, at market price. The Pune metro project will now cost Rs 11, 522 crores, up from Rs 10,183 crores

estimated in 2013. The delay in the execution of the project has resulted in an upward revision of Rs 1,700 crores in the draft civic budget for 2015-16 presented by municipal commissioner Kunal Kumar.

4.3 Questionnaire Survey:

A pilot questionnaire survey was conducted amongst professionals with work experience in metro 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. Total response collected 57 no's detail as below:

Respondent's Details			
SI No	Details	Frequency	Percentage
Gender			
1	Male	48	84.21
2	Female	9	15.79
Stake Holder			
1	Client	10	17.54
2	Consultant	26	45.6
3	Contractor's Manager	6	10.52
4	Contractor's Engineer	15	26.34

Table 1 Respondent's Details

Relative Importance Index & Ranking of Factors based on Questionnaire Survey																					
Factor No	Description	No of Respondent For Scoring					Respondent Scoring					Percentage of Respondent Scoring					Total Scoring	Total Respondent	A*N	RII	Ranking
		Strongly disagree	Disagree	Not sure	Agree	Strongly Agree	Strongly disagree	Disagree	Not sure	Agree	Strongly Agree	Strongly disagree	Disagree	Not sure	Agree	Strongly Agree					
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5					
F1	Change in Scope	2	10	4	24	17	2	20	12	96	85	0.93	9.30	5.58	44.65	39.53	215	57	285	0.754	7
F2	Delay in Land acquisition and site Handover to Contractor	2	7	0	13	35	2	14	0	52	175	0.82	5.76	0.00	21.40	72.02	243	57	285	0.853	3
F3	Covid19 Pandemic		3	0	12	42	0	6	0	48	210	0.00	2.27	0.00	18.18	79.55	264	57	285	0.926	1
F4	Obtaining permits from local bodies	4	12	0	9	32	4	24	0	36	160	1.79	10.71	0.00	16.07	71.43	224	57	285	0.786	6
F5	Litigation and decision delays	6	10	10	12	19	6	20	30	48	95	3.02	10.05	15.08	24.12	47.74	199	57	285	0.698	8
F6	Design approvals and decision making	9	10	6	17	15	9	20	18	68	75	4.74	10.53	9.47	35.79	39.47	190	57	285	0.667	11
F7	Negotiations time lapse for award of work	8	12	7	16	14	8	24	21	64	70	4.28	12.83	11.23	34.22	37.43	187	57	285	0.656	13
F8	Approving overall designs and shop drawing	9	10	5	19	14	9	20	15	76	70	4.74	10.53	7.89	40.00	36.84	190	57	285	0.667	12
F9	Repeated revision of drawings and Inputs	8	16	10	12	11	8	32	30	48	55	4.62	18.50	17.34	27.75	31.79	173	57	285	0.607	16
F10	Lack of data collection and survey before design	10	14	10	12	11	10	28	30	48	55	5.85	16.37	17.54	28.07	32.16	171	57	285	0.600	17
F11	Delay in payments	12	14	11	12	8	12	28	33	48	40	7.45	17.39	20.50	29.81	24.84	161	57	285	0.565	18
F12	Performing final inspection and certification by a third party	16	13	13	9	6	16	26	39	36	30	10.88	17.69	26.53	24.49	20.41	147	57	285	0.516	20
F13	Difficulties in financing	15	12	16	12	2	15	24	48	48	10	10.34	16.55	33.10	33.10	6.90	145	57	285	0.509	21
F14	Project/company insolvency	16	12	14	14	1	16	24	42	56	5	11.19	16.78	29.37	39.16	3.50	143	57	285	0.502	22
F15	Shortage of Plant and Machineries	8	12	7	18	12	8	24	21	72	60	4.32	12.97	11.35	38.92	32.43	185	57	285	0.649	14
F16	Unanticipated Equipment breakdown and their idle time	15	22	8	11	1	15	44	24	44	5	11.36	33.33	18.18	33.33	3.79	132	57	285	0.463	24
F17	Conflicts with other stakeholders	19	16	5	13	4	19	32	15	52	20	13.77	23.19	10.87	37.68	14.49	138	57	285	0.484	23
F18	Unavailability of Land for casting of prefabricated structures	8	10	7	18	14	8	20	21	72	70	4.19	10.47	10.99	37.70	36.65	191	57	285	0.670	10
F19	Inadequate management and supervision	22	18	8	9	0	22	36	24	36	0	18.64	30.51	20.34	30.51	0.00	118	57	285	0.414	27
F20	Performing site inspection & testing of material	16	20	10	10	1	16	40	30	40	5	12.21	30.53	22.90	30.53	3.82	131	57	285	0.460	25
F21	Rework due to errors	16	13	10	9	9	16	26	30	36	45	10.46	16.99	19.61	23.53	29.41	153	57	285	0.537	19
F22	Shortage of labour	2	3	0	20	32	2	6	0	80	160	0.81	2.42	0.00	32.26	64.52	248	57	285	0.870	2
F23	Heavy traffic, over-crowd & other restrictions on site.	2	7	6	14	28	2	14	18	56	140	0.87	6.09	7.83	24.35	60.87	230	57	285	0.807	5
F24	Shortage of construction materials (Like Steel, Cement, Aggregate)	3	6	2	20	26	3	12	6	80	130	1.30	5.19	2.60	34.63	56.28	231	57	285	0.811	4
F25	Delay in material delivery especially while importing Material transport issues in congestion hours during day.	16	22	8	10	1	16	44	24	40	5	12.40	34.11	18.60	31.01	3.88	129	57	285	0.453	26
F26	Contractor's Economic crisis	8	8	7	21	13	8	16	21	84	65	4.12	8.25	10.82	43.30	33.51	194	57	285	0.681	9
F27	Social and cultural impacts	12	10	9	14	12	12	20	27	56	60	6.86	11.43	15.43	32.00	34.29	175	57	285	0.614	15

Table .2 Relative Importance Index and Ranking Factor

The analysis of the critical factors from the perspective of client, consultants and contractors indicates that Delay due to Covid19 Pandemic is the most critical factor in delay. The opinion of contractors suggests that Shortage of labour is the second most responsible factor for delays. In some cases, Shortage of labour, Delay in Land acquisition and site Handover to Contractor, Shortage of construction materials (Like Steel, Cement, Aggregate), Heavy traffic, over-crowd & other restrictions on site. are the other most critical factors of delay as per the opinion of clients, contractors and consultants. During the construction phase of the projects, more no of 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 influence on the schedule compliance of the project and intensify delays. Metro rail projects are also accustomed 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.

V. RESULTS AND DISCUSSION

5.1 Some Respondent's response of questioner as below:

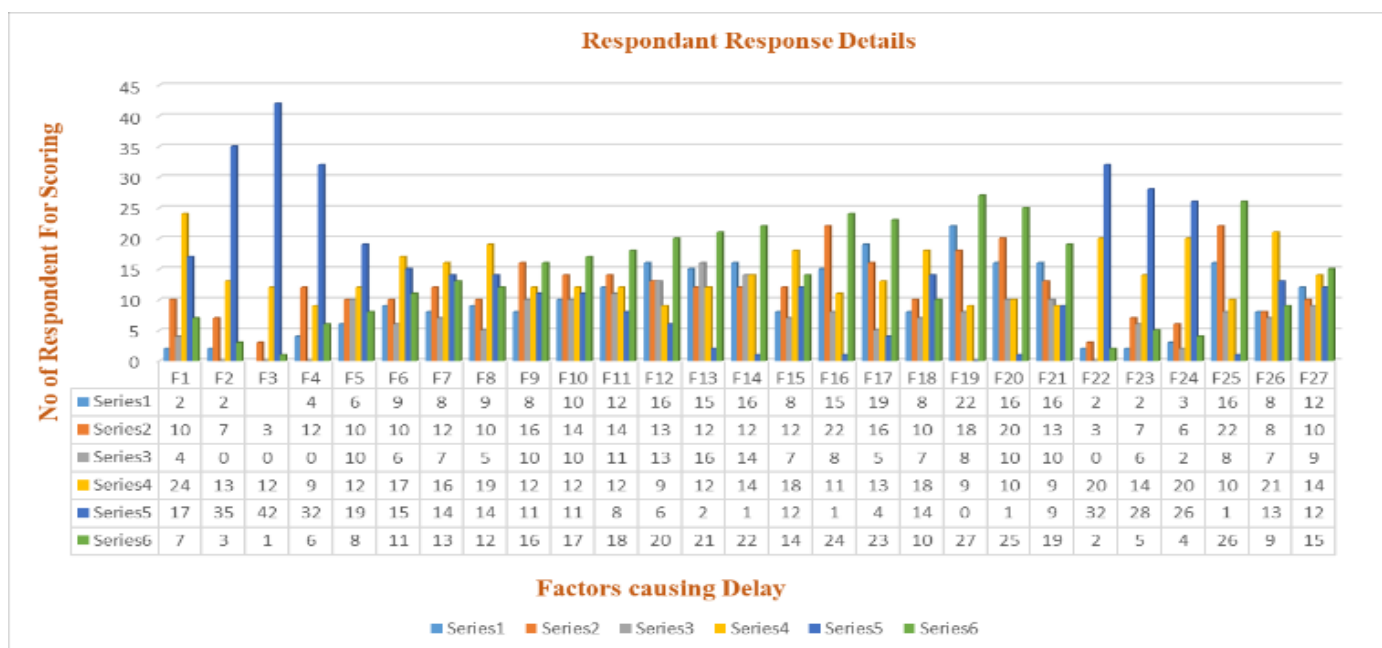


Figure 1- Respondent Response Details

5.2 Ranking of Factors:

Ranking Comparison Between Critical Factors						
SI No	Factor Level	Cause of Delay	Ranking			
			Over All	Client	Consultant	Contractor
1	F3	Covid19 Pandemic	1	1	1	1
2	F22	Shortage of labour	2	2	2	2
3	F2	Delay in Land acquisition and site Handover to Contractor	3	3	3	3
4	F24	Shortage of construction materials (Like Steel, Cement, Aggregate)	4	4	4	4
5	F23	Heavy traffic, over-crowd & other restrictions on site.	5	5	5	5
6	F4	Obtaining permits from local bodies	6	8	6	6
7	F1	Change in Scope	7	7	8	7
8	F5	Litigation and decision delays	8	6	10	8
9	F26	Contractor's Economic crisis	9	9	9	12
10	F18	Unavailability of Land for casting of prefabricated structures	10	11	7	13
11	F6	Design approvals and decision making	11	10	11	9
12	F8	Approving overall designs and shop drawing	12	14	14	10
13	F7	Negotiations time lapse for award of work	13	18	13	11
14	F15	Shortage of Plant and Machineries	14	12	12	18
15	F27	Social and cultural impacts	15	15	15	14

Table .3 Ranking comparison between critical 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 due to Covid19 Pandemic (RII = 0.926); (2) Shortage of labour (RII = 0.87); (3) Delay in Land acquisition and site Handover to Contractor (RII - 0.853); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.811) (5) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.807). The five most critical factors of delay from the perspective of consultant were: (1) Delay due to Covid19 Pandemic (RII = 0.926); (2) Shortage of labour (RII = 0.87); (3) Delay in Land acquisition and site Handover to Contractor (RII - 0.853); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.811) (5) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.807). The five most critical factors of delay from the perspective of the contractor were: ((1) Delay due to Covid19 Pandemic (RII = 0.926); (2) Shortage of labour (RII = 0.87); (3) Delay in Land acquisition and site Handover to Contractor (RII - 0.853); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.811) (5) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.807).

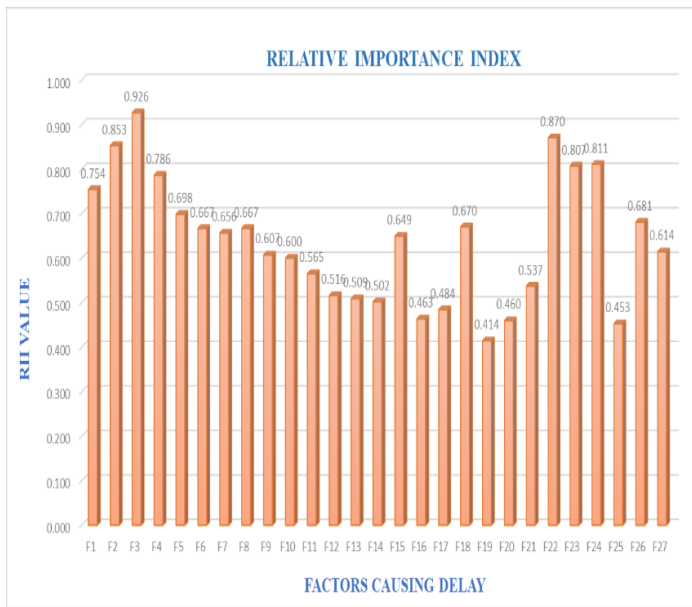


Figure 2-Shows Relative Importance

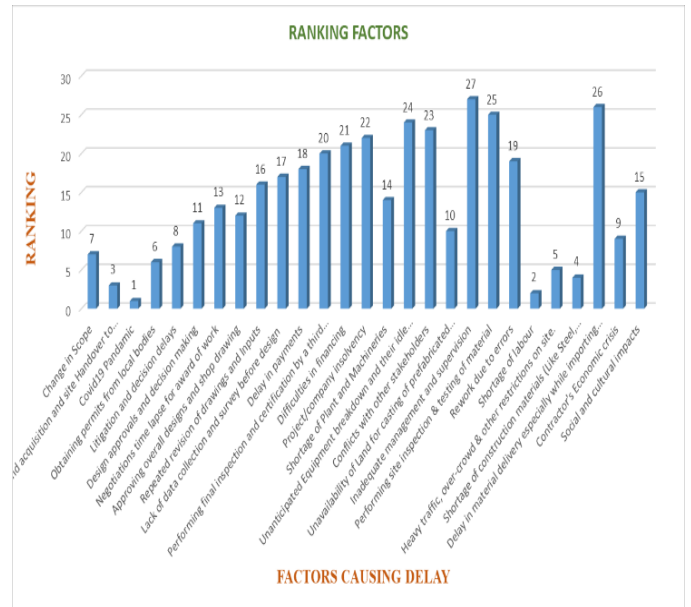


Figure 3-Shows Ranking Factor

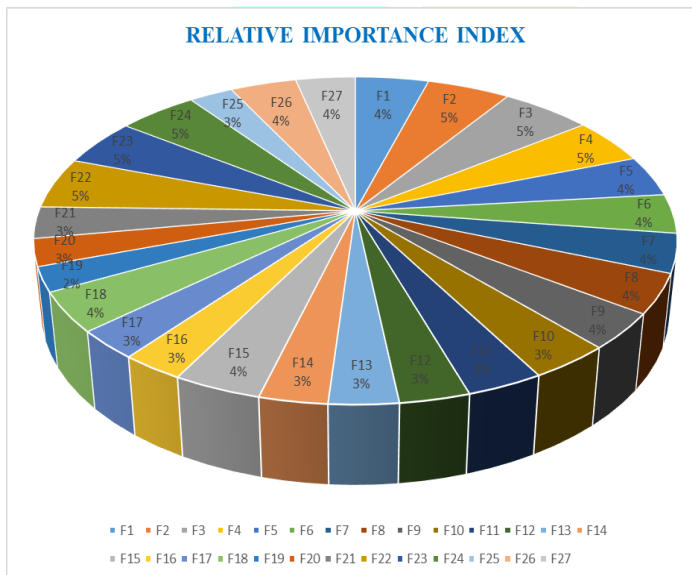


Figure 4-Shows Relative Importance

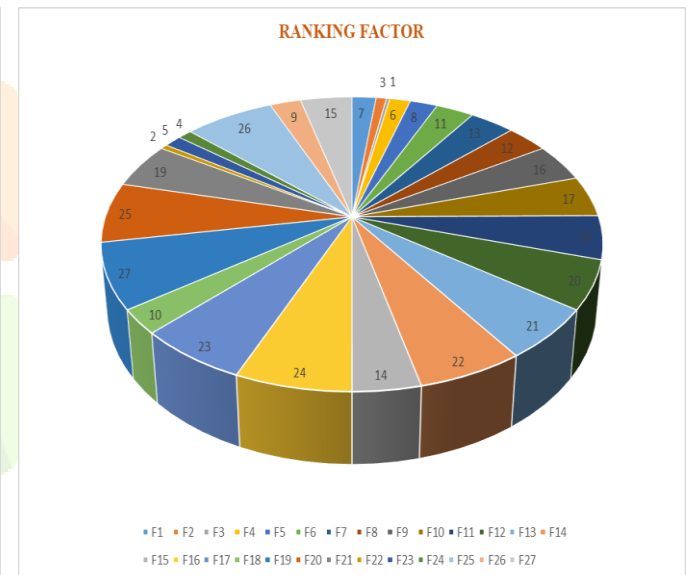


Figure 5-Shows Ranking Factor

5.3 Result based on most critical causes of Delay

The ten most critical factors of delays (based on all respondents) as shown in the Table 2 are: (1) Delay due to Covid19 Pandemic (RII = 0.926); (2) Shortage of labour (RII = 0.87); (3) Delay in Land acquisition and site Handover to Contractor (RII - 0.853); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.811) (5) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.807), (6) Obtaining permits from local bodies (RII 0.786), (7) Change in Scope (RII = 0.754), (8) Litigation and decision delays (RII - 0.698), (9) Contractor's Economic crisis (RII-0.681), and (10) Unavailability of Land for casting of prefabricated structures (RII = 0.670). This section discusses the details of the critical factors of delay in Pune metro rail projects.

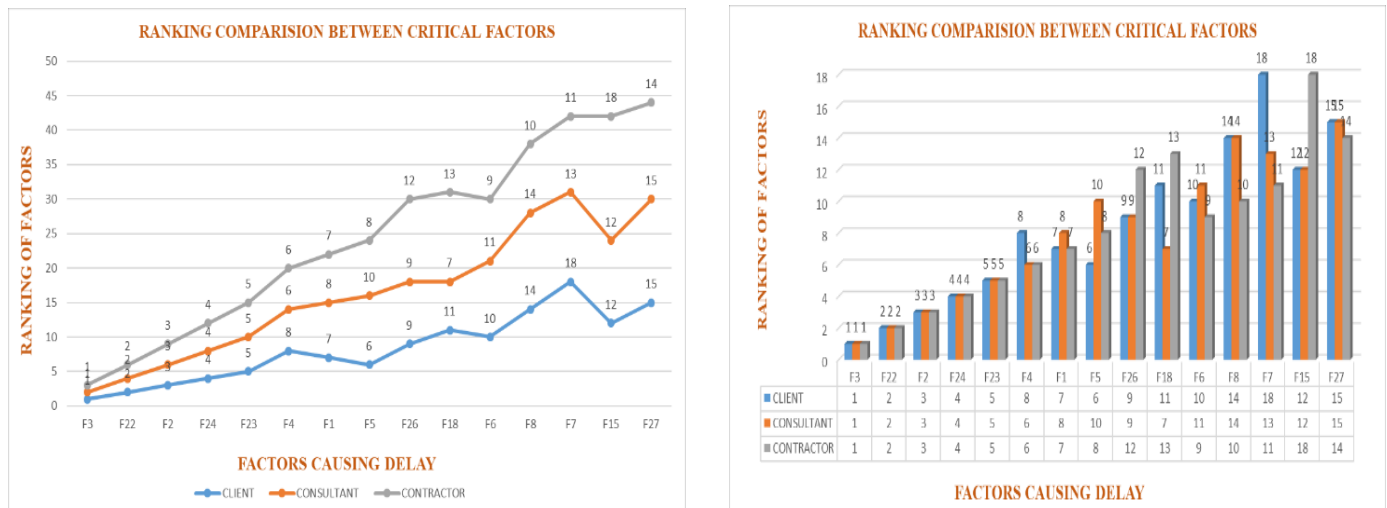


Figure 6 & 7 -Shows Ranking Comparison between critical Factors

5.4.1 Delay due to Covid19 Pandemic

Impacts of COVID-19 on construction sector are becoming more numerous by the day, which is having an influence on the Metro Projects. Government lockdowns are disrupting the supply chain; labour shortages are emerging; companies are experiencing an economic downturn and they are having difficulty keeping their contracts also. However, in the present situation of the COVID-19 pandemic continuing for over one-and-a-half years, it can no longer be taken as an excuse to claim extension of time and damages. A prudent contractor ought to have enough knowledge about the practical ground realities of the construction project. While bidding for a new project, the contractor ought to undertake proper due diligence, inspection and independent assessment, to assess the possible hindrances/ failures which would disentitle the contractor from claiming damages and/or additional compensation.

5.4.2 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. Due to covid19 lockdown supply of labour also break. Metro rail projects are more affected by the shortage of skilled labour.

5.4.3 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.

5.4.4 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.

5.4.5 Heavy traffic, over-crowd & other restrictions on site

Due to heavy traffic and over crowd in day time only 5 hrs road permission given for Metro works. The speed of work also hampered. For this reason, transportation of construction equipment also delayed which leads delay in projects

5.4.6 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.

5.4.7 Change in Scope

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.

5.4.8 Litigation and decision delays'

Disagreement or arbitration lead to litigation and decision delays which is mainly due to lack of clarity in contract conditions or interpretation by respective parties. The problem could be resolved with well defined contract clauses and time saving arbitration mechanism.

5.4.9 Contractor's Economic crisis

Due to economic crisis of contractor material supply, labour payment, vendor's dues clearance delayed. So labour and material supply slower which leads to project delay.

5.4.10 Unavailability of Land for casting of prefabricated structures

In Metro cities available of Big lands are less. So requirement of land not properly fulfilled. Due to delay in projects prefabricated structures occupied all land. So further work was hampered due to shortage of stacking land which leads to delay in projects.

5.4.11 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 Fiber Cable) line, etc.

5.4.12 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.

5.4.13 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.

5.4.14 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.

5.4.15 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.

5.5 Calculation of value of lost time in work zone

Pune has seen colossal modern development amid the most recent 10 years. Quick urbanization in the on-going past has put the movement framework to push. With countless have come up both in little scale just as in substantial and medium scale industry, and so on traffic in the city is required to shoot up. Being thickly populated zone, Pune traffic needs can't be met by just street based framework.

The current urban transport arrangement of Pune City which is street based has just gone under pressure prompting longer travel time, expanded air contamination and ascend in number of street mishaps. With anticipated increment in the number of inhabitants in the city fortifying and enlarging of transport framework has expected criticalness. For this reason arrangement of rail-based Metro framework in the city has been considered.

The task has numerous positive ecological effects like decrease in rush hour gridlock blockage, sparing in movement time, decrease in air and commotion contamination, lesser fuel utilization, lesser absolute mishaps and so forth with a couple of negative effect (particularly because of usage period of the undertaking) for which Environment Management Plan has been proposed.

After analyzing the different choices for execution of Pune Metro Project, it has been suggested that the task ought to be got executed through a SPV on DMRC financing design.

The passage structure has been evaluated dependent on Delhi Metro tolls chosen by the charge obsession council in 2009 properly heightening the equivalent for year 2018. In this way, to assess comes back from the task, the tolls have been updated each second year with an acceleration of 12 % at regular intervals

5.6 Cost-Benefit Analysis

One of the key justifications given by the DPR for its proposal is a socioeconomic cost benefit analysis which shows that the socioeconomic benefit of the project outweighs its costs. The costs regulated in the DPR are the capital and operational costs, while societal benefits are said to arise from various categories such as savings in fuel, time, vehicle maintenance cost and infrastructure maintenance cost. It is questionable that how much productive use can be made of the few minutes saved per trip by a person, and

whether items such as reduced vehicle maintenance costs should even be considered. Moreover, the costs considered in the DPR do not include costs such as the cost of capital.

Even if we overlook these discrepancies, the cost benefit analysis given in the DPR is defective. The DPR estimates total benefits to society from the metro rail in 3 horizon years ie. 2011, 2021 and 2031. It is seen that the benefit claimed for 2011 is vastly over estimated – the same analysis also applies to the other years. Analysis of the three categories (time savings, vehicle maintenance savings and fuel savings) with the largest claimed benefits and provide alternative estimates using data from the DPR itself such as trip length distribution and metro rail ridership, augmented with a set of orthodox assumptions such as fuel cost of Rs. 60/L, average mileage of 45 kmpl and annual maintenance cost of Rs. 3000 for two wheelers, and 10 kmpl and Rs. 15000 for cars. Other assumptions made are explained at appropriate locations below.

5.7 Time Savings

DPR, the benefit of value of time saved by shifting to metro rail from other modes; each metro rail trip is estimated to save 45 min in 2011 and the claimed money equivalent savings of the aggregate annual time saved adds up to 56% (Rs. 524 cr) of the total claims annual benefit (Rs. 934 cr). This includes not simply time saved in travel but also the walking and waiting time for one's transport and money or time equivalent of factors such as travel comfort. Many reports, including a study commissioned by DMRC, state that Pune's average peak hour road speed is about 20-25 kmph, while the speed of the proposed metro rail is 33 kmph [10, 11, 3, 2]. The DPR also states that 75% of journeys are shorter than 9 km.

Assuming an average speed of 20 kmph for other modes, 75% of journeys would take a maximum of 27 min by other modes and whereas 16 min by metro rail. Therefore, the travel time saving is just 11 min for 75% of the journeys. Metro rail users who have shifted from two wheelers or cars would not save any time in walking to the metro rail station and waiting for a train – in fact, they would lose time.

Given that peak hour ridership estimated for the metro rail is based on dense loads of 8 persons per sq. m, they would also not gain anything from added travel comfort. Therefore, the maximum saving for all such metro rail users would be at most 11 min over 75% of journeys, with actual savings even lower due to reduced time savings and comfort. Users who have shifted from buses could perhaps have some time equivalent saving due to higher waiting times and discomfort factors, though their walking times are likely to increase since bus stops are likely to be closer to homes and offices than metro rail stations. Even the higher waiting time and discomfort factors are questionable because:

- a) Peak hour headway of the proposed metro rail corridors is only 4 and 8 min in 2031, which a bus system can easily match and
- b) The metro rail is designed for dense loads of 8 persons per sq. m which is comparable to buses at peak hour. Even if we conservatively assume that all bus users pay a penalty of 15 min per trip (10 min for waiting and 5 min for discomfort), 75% of bus users switching to metro rail would have a time equivalent saving of only 26 min as their journeys would be less than 9 km. It is obvious that the time savings component presented in the DPR is vastly over stated. A detailed analysis shows that even if all the metro rail trips by users who switched from buses (thus providing maximum time savings), the total time savings in 2011 comes only to Rs. 273 cr against the claimed Rs. 524 cr savings.

VI. CONCLUSION

Construction projects often agonize from delays due to a wide variety of reasons, which can have severe financial impact on the project. As a result, delay claims may be filed. But delays can be avoided when their causes are clearly identified. However, in case of delays the analysis of its impact, the causes, and effects of the delaying activities is one of the most complicated types of claims analysis. The aim of this paper is to identify the delay factors in metro projects and introduction type of delay analysis methods for applying more reliable and precise techniques to reduce the frequency and to mitigate the severity of disputes and litigation due to delay claims because delays are considered to be a serious problem in the construction industry.

Hence through a detailed literature review and interviews with experts from professionals with work experience in rail based projects to consolidate the list of factors, a total of 27 different delay factors were identified and categorized into three groups the field survey included 21 contractors, 26 consultants and 10 clients. Data collected were analyzed by RII and SPS. We identified ten main causes of delay.

The paper represents the results of a study on the identification of critical delay factors and their ranking for the case of Pune metro rail projects. The RII of 27 factors suggests that 1) Due to Covid19 Pandemic 2) Shortage of Labour 3) Delay in Land acquisition and site Handover to Contractor 4) Shortage of construction materials (Like Steel, Cement, Aggregate) and 5) Change in Scope of Project are the five top critical factors of delay in metro rail projects by questionnaire method. The category of factors was also derived by ranking and found Owner, material and external related factors were also responsible for the delay.

By using Expert project managerial skill, setting realistic goal of project, Schedule properly, Effective team meeting, Gather the right resources on time, Track and measure progress daily basis, adopting new technologies delay of projects can be minimized. India's urbanization is outpacing its urban government structures, systems, and capacities. This results in massive, expensive initiatives that often don't achieve the claimed benefits and overlooking smaller, faster alternatives that may be more useful.

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