“IDENTIFICATION AND ANALYSIS OF ROOT CAUSES OF DELAY IN MUMBAI METRO LINE 4”

1Mr. Prashant Kachare, PG Student, M.E. (Construction management)  
Department of Civil Engineering  
Imperial College of Engineering & Research, Wagholi Pune,

2Prof. V. R. Payghan  
PG Coordinator, (Construction Management)  
Assistant Professor, Department of Civil Engineering  
Imperial College of Engineering & Research Wagholi Pune

3Dr. Navnath. V. Khadke  
Head of Department of Civil Engineering  
Imperial College of Engineering & Research Wagholi Pune

Abstract: To identify the major causes of delays in construction projects in India; the major causes of delays in this research study were investigated following data collection carried out through a questionnaire survey with a wide range of construction professionals based in Metro Projects. The findings from this research determined the major causes of delays based on an importance index, and the main conclusions from the output of the data could help the construction sector to better assess not only the major causes of delays on construction projects but also how to minimize them by proper planning. There may, however, be opportunities for safer working practices arising from a new awareness of health, hygiene, and safety risk. The role of safety leadership is overlooked in guidance yet is vital to ensure safe the application of working practices.

In the present scenario, apart from addressing the increased requirement Delay factors can be minimized by proper decision-making throughout the construction process but further research is required. This could include research into the communication of decisions, the content of training programs for construction site managers, the value of apprenticeship schemes to provide a more skilled workforce, the possibilities of greater use of pre-cast materials, etc. this study identified the causes of delays on construction projects in India during a pandemic.

As metro projects are much essential part of the city, it needs to be completed at the earliest for public benefit. Almost all metro projects in India are facing delays. Delay is generally considered the most common, complex, and risky problem encountered in construction projects. Most construction projects in developing countries are characterized by overruns in time. All projects, regardless of size and complexity are burdened by deadlines and uncertainty. Delays occur in every construction project and the magnitude of these delays varies considerably from project to project. This research carries out a detailed review of the previous studies on the time and cost overrun factors.

Keywords- Delay, Metro, Cost, Time, budget, Management, Risk Management, Planning, Quality, Schedule

I. INTRODUCTION

The construction industry is repeatedly criticized for being inefficient and slow to innovate.

The term advanced construction technology covers a wide range of modern techniques and practices that encompass the latest developments in materials technology, design procedures quantity surveying, facilities management services, cost-effective, structural analysis, and design and management studies.

Key points for advanced construction techniques
1. Improved job-site efficiency through more effective interfacing of People, Processes, Materials, Equipment, and information
2. Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and process
3. Widespread deployment and use of interoperable technology application
4. Innovative, widespread use of demonstration installations
5. Effective performance measurement to drive efficiency and support innovation
6. It is a project delivery strategy to start construction before the design is complete.
7. The purpose is to shorten the time to completion
8. The final cost of the project is uncertain when construction begins because the design is not complete.
9. Fast-Track is more difficult to manage than the traditional design bid build process. It requires detailed knowledge of the process, effective planning, integrity, and close coordination among the organizations executing the work.

The Impact of the pandemic situation on the construction industry; the global impact of the pandemic; the impact of global impact, and the prospects of the economy; the study covers the impact on global and regional economies. The construction industry and its economic prospects are also discussed in the global pandemic.

The major causes of delays are based on importance and relative index, and the main conclusions from the output of the data could help the construction sector to better assess not only the major causes of delays in construction projects but also how to minimize them by proper planning.

The most common factor of delay is a natural disaster in the construction industry like flood and earthquake and some others like financial and payment problems, improper planning, poor site management, insufficient experience, shortage of materials and equipment, etc. We cover the delay factors and causes of delay and some suggestions for reducing these delays in metro construction projects.

The importance of applying proper management in dealing with delays in construction for a growing economy; the main objective of this paper is to identify the management tools that are practiced in the local construction industry in mitigating delays. It also aims to identify the main factors that lead to project delays and to suggest recommendations on how to overcome or mitigate the effects of the problem.

The purpose of this study was to explore the causes of delay risk through a field survey study. Data were collected from construction professionals working in owner, consultant, and contractor organizations. All together questionnaire instruments were used and analyzed by employing statistical tools (SPSS computer program).

Construction projects delay presents the relationship between new technology and time overruns in those projects. One of the main causes of delay in many projects is that they use an old generation of construction technologies; however, the role of technology adoption in the delay is ignored. Lack of efficient construction planning plays the second key role in adverse time performance. While the effect of lack of commitment on contractor’s inefficiency is highly significant, neither of these two factors has any direct impact on time delay in projects.

1.1 Aim:
“To effectively rank the many causes of delays, identify the most important causes, project stages where delays can occur, and their treatments. Metro Line 4 Case Study

1.2 Objectives:
1. To identify the causes of delay in Mumbai Metro Line 4
2. To find the factor that delays construction activity in Mumbai Metro Line 4 and overcome these factors with advanced construction technology
3. To identify the fundamental causes of construction delays in the Mumbai Metro Line 4 Project by using the relative importance index, SPSS Software, and questionnaires survey.
4. To find the solution to overcome delays with advanced construction technology

II. RESEARCH METHODOLOGY

2.1 Problem Statement
“To study economic feasibility for metro construction; the study addresses the factors that determine location, the attributes that enhance rail use through satisfaction and financial analysis, presents the social impacts and their requirements for the achievement of the social objectives-, and discusses the benefits social, economic, environmental that are accrued from the existence of metro Construction.”
2.2 Research Methodology

III. DATA COLLECTION & ANALYSIS

3.1 Questionnaire Survey
- Among the many available methods for collecting data two methods were adopted; these are literature review and questionnaires.
- The first step involves general information collection, including both first-hand and second-hand data, to identify major themes from the literature.
- In the second step, with the literature review and unstructured reviews, important factors of safety were identified. With these factors, a questionnaire was formed and Survey was conducted through Google form or any other.
- The Google form questionnaires will distribute through various electronic media platforms to a variety of respondents working around the construction projects.

3.2 PILOT SURVEY AND QUESTIONNAIRE REVISION
- To improve the questionnaire section, a pilot study was accompanied. This section contained identification of different causes, collection, and conclusions of data.
- Questionnaires were sent to laborers, contractors, government employees, project managers, evaluators, and project engineers at the metro project.
- To get a more suitable and consistent meaning some factors should be rearranged.
- Some factors should be changed to give clearer importance and understanding. A better and more accurate questionnaire related to the topic was achieved from the pilot study.
- The perfections related to the organization of the questionnaire and the response time.

3.3 SPSS SOFTWARE
Analysis of the questionnaire survey was done using IBM SPSS Software. SPSS Statistics is a software package used for statistical analysis.
The software name originally stood for Statistical Package for the Social Sciences (SPSS).

SPSS data View: The questionnaire survey responses were reported in an excel file.
SPSS Variable View:

An SPSS data file always has a second sheet called variable view. It shows the metadata associated with the data. Metadata is information about the meaning of variables and data values.

In Variable View, different columns are displayed. Each line corresponds to a variable. A variable is simply a quantity of something, which varies and can be measured, such as:

SPSS Data analysis

- SPSS can open all sorts of data and display them—and their metadata—in two sheets in its Data Editor window.
- In our data contain a variable holding respondents’ on emergency services in pandemic situations related question.
SPSS Output Window

SPSS output viewer window. It holds a table with all statistics on all variables we chose. The Output Viewer window has a different layout and structure than the Data Editor window.

Creating output in SPSS does not change our data in any way; unlike Excel, SPSS uses different windows for data and research outcomes based on those data.
3.4 RII Manual Method

- The sample for this study is relatively small. As a result, the analysis combined all groups of respondents (clients, consultants, contractors, and regulatory boards) to obtain significant results.
- Data was analyzed by calculating frequencies and the Relative Importance Index (RII). The data analysis was carried out using SPSS.
- SPSS was used to generate the frequency (fi) of the response category index for the cause and effect factors. The relative importance index (RII) for each factor was calculated using the frequency data for each response category generated from SPSS.
- Data analysis was done by calculating the Relative Important Index (RII) by the following formula.

RII = ∑W / A * N

Where, W = weight given to each factor by respondents (1-3)

∑W = 5 × W5 + 4 × W4 + 3 × W3 + 2 × W2 + 1 × W1

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 = highest weight (i.e. 5)
N = total number of respondents (Ex. 100)

3.4.1 SURVEY QUESTIONS

Manager’s Questionnaire Survey:

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

3.4.2 Ranking of Factors:

<table>
<thead>
<tr>
<th>SR. No.</th>
<th>Details</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Male</td>
<td>55</td>
<td>78.57</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>15</td>
<td>21.42</td>
</tr>
<tr>
<td>Stake Holder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Client</td>
<td>14</td>
<td>20.00</td>
</tr>
<tr>
<td>2</td>
<td>Consultant</td>
<td>28</td>
<td>40.00</td>
</tr>
<tr>
<td>3</td>
<td>Contractor's Manager</td>
<td>10</td>
<td>14.28</td>
</tr>
<tr>
<td>4</td>
<td>Contractor's Engineer</td>
<td>18</td>
<td>25.71</td>
</tr>
</tbody>
</table>

Table 1 Respondents Details
Table 2 Relative Importance Index and Ranking Factor

3.4.3 SPSS RESULTS FOR MANAGERIAL QUESTIONNAIRE:

Do you think Delay in Land acquisition and site Handover to the Contractor?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not Sure</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Agree</td>
<td>32</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>64</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Do you think the Tree Permission Delayed the Metro works?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Not Sure</td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Agree</td>
<td>40</td>
<td>40</td>
<td>47</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>53</td>
<td>53</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Do you think the Metro project was delayed due to the Covid19 Pandemic?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Not Sure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Agree</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>57</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Is the project delayed due to a change in the Scope of the Metro works?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Not Sure</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Agree</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>62</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Do you think Obtaining permits from local bodies delayed the project?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Disagree</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Not Sure</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Agree</td>
<td>46</td>
<td>46</td>
<td>46</td>
<td>70</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PIE CHART: Managerial Questionnaire:

Do you think Delay in Land acquisition and site Handover to the Contractor?

- 1: 23% (64)
- 2: 0%
- 3: 4%
- 4: 32%
- 5: 5%

Do you think the Tree Permission Delayed the Metro works?

- 1: 23% (53)
- 2: 0%
- 3: 12%
- 4: 40%
- 5: 0%
3.5 CASE STUDY

Details of Project:
- Metro Line 4 – Wadala–Ghatkopar-Mulund-Thane– Kasarvadavali
- Total Cost: - Rs. 14,549 cores,
- Total Length: - 32.32 km (Fully Elevated with 30 Nos stations)
- Depot location for Line-4 & 4A: Mogharpada
  - Interchange Stations with Other Metro Line
    - Bhakti Park (Line-11) & (Monorail)
    - Kurla EEH (Metro Line 2B)
    - Gandhi Nagar (Metro Line 6)
    - Kapurbawdi (Metro Line 5)
- Metro Line 4a – Kasarvadavali Gaimukh
- Total Cost: -Rs. 949 cores, Total Length: - 2.70 km + 1.5 km Depot Connectivity (Fully elevated with 2 stations)

IV. RESULTS AND DISCUSSION

4.1 Ranking of Factors

The data collected from the questionnaire is categorized into three sets based on the stakeholder represented by the respondent (i.e. clients, consultants, and contractors). RII value for all the factors was calculated for the identification of the most critical factors of delay in metro rail projects. The factors were listed in the decreasing order of their value of RII and ranked. The five most critical factors of a delay from the perspective of clients were: (1) Delay in Land acquisition and site Handover to Contractor (RII =
0.920); (2) Tree Permission (RII = 0.880); (3) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.871); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.869) (5) Change in Scope (RII - 0.860).

4.2 Result based on most critical causes of Delay

The ten most critical factors of delays (based on all respondents) as shown in Table 6.2 are (1) Delay in Land acquisition and site Handover to Contractor (RII = 0.920); (2) Tree Permission (RII = 0.880); (3) Heavy traffic, over-crowd & other restrictions on site. (RII - 0.871); (4) Shortage of construction materials (Like Steel, Cement, Aggregate) (RII - 0.869) (5) Change in Scope (RII - 0.860), (6) Covid19 Pandemic (RII 0.867), (7) Delay in material delivery, especially while importing Material transport issues in congestion hours during the day (RII = 0.854), (8) Delay in payments (RII - 0.846), (9) Contractor's Economic crisis (RII-0.840), and (10) Weather condition (RII = 0.837). This section discusses the details of the critical factors of delay in Mumbai Metro Line 4 rail projects.

4.2.1 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 the case of Hyderabad Metro, property acquisition issues in Line 3 Blue Line-Nagole to Raidurg are causing delays.

4.2.2 Shortage in construction material

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

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

Due to heavy traffic and over crowd in day time only 6 hrs road permission given for Metro works. The speed of work was also hampered. For this reason, transportation of construction equipment is also delayed which leads to delays in projects.

4.2.4 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 varies largely with respect to the location of projects as the procedure followed and the number of approvals required are different for different administrative settings.

4.2.5 Change in Scope

Change in plans by the 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 changes in government regulations, financial issues, etc. In other cases, a lack of a 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.

4.2.6 Litigation and decision delays

Disagreement or arbitration leads to litigation and decision delays which are mainly due to a 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.
V. CONCLUSION

The aim of this paper is to identify the delay factors in metro projects and introduce a type of delay analysis methods for applying more reliable and precise techniques to reduce the frequency and 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 35 different delay factors were identified and categorized into three groups the field survey included 28 contractors, and 28 consultants and 14 clients. Data collected were analyzed by RII and SPSS. 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 in the case of the Mumbai Metro Line 4 project. The RII of 35 factors suggests that 1) Delay in Land acquisition and site Handover to Contractor 2) Tree Permission 3 Heavy traffic, over-crowd & other restrictions on site.4) Shortage of construction materials (Like Steel, Cement, and Aggregate) and 5) Covid19 Pandemic 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 skills, setting a realistic goal of the project, Scheduling properly, Effective team meetings, Gathering the right resources on time, Tracking and measuring progress daily basis, and adopting new technologies delays in projects can be minimized. India's urbanization is outpacing its urban governance 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.
ACKNOWLEDGMENT

While working on this paper to its final formation, I would like to thank those who contributes to this research. It is a pleasure to convey my gratitude to all of them. I am indebted to my guide Prof. V. R. Payghan and the Head of the Department Dr. N. V. Khadke who have motivated me to do his research. It is quite difficult to express my gratitude in a few words. Last but not the least; I am thankful to all my Professors and non-teaching staff members in the department whose help provided to be an advantage in completing the project. Also, I would like to acknowledge the moral support of my parents and friends. I am thanks again to all people who helped me during this paperwork.

REFERENCES

[14]. Eskesen, S D et al. (2016) Guidelines for tunneling risk management, ITA Working Group 2, Research, ITA-AITES, c/o EPFL, Bat GC, CH 1015 Lausanne, Switzerland