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"Analysis Of Causes Of Time And Cost Overrun In Pune Metro Project"

[1]Mr. Akash pandurang kokane, [2]Prof. Rahul D. shinde

[1]PG Student, [2]Assistant proffeser,
[1] Civil Engineering Department,
[1]RMD School of engineering, waje, pune, India

Abstract— to identify the major causes of delays on construction projects in India; the major causes of delays from 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 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 practice arising from new awareness of health, hygiene, and safety risk. The role of safety leadership is overlooked in guidance yet is vital to ensure safe 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 programmes 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 pandemic.

As metro projects are much essential part of city, it needs to be completed at earliest for public benefits. Almost all metro projects in India are facing delay. Delay is generally considered as 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, 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 of the time and cost overrun factors.

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

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 advance construction techniques
1. Improved job-site efficiency through more effective interfacing of people, Process, 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 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 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 pandemic situation on the construction industry; the global impact of pandemic; the impact of global impact, and the prospects of 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 based on an importance and relative index, and the main conclusions from 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.

The most common factor of delay are natural disaster in 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 suggestion 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 delay. It also aims to identify the main factors that lead to project delays and to suggest recommendations on how to overcome or mitigate 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 overrun 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 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.

What is Statistics?
Statistics is a tool for creating new understanding from a set of numbers. Statistics can be better understood under two branches:

1. Descriptive Statistics
2. Inferential Statistics

MEAN (Arithmetic Average):

Mean is the arithmetic average computed by summing all the values in the dataset and dividing the sum by the number of data values. For a finite set of dataset with measurement values X1, X2, …., Xn (a set of n numbers), it is defined by the formula:

$$\mu_x = \sum_{i=1}^{N} \frac{x_i}{N} = \frac{x_1 + x_2 + \ldots + x_N}{N}$$

MEDIAN
The middle number in the data set (n/2), when arranged in ascending order (small to large). If there are odd numbers of observations then median is the (n+1)/2th ordered value. If there are even numbers of observations then median is average of the two middle values.

MODE

Mode is the data point having the highest frequency (maximum occurrences).

QUARTILES

A quartile is any of the three values which divide the sorted data set into four equal parts, so that each part represents one fourth of the sampled population.

STANDARD DEVIATION
It can be interpreted as the average distance of the individual observations from the mean. Standard deviation of the population is represented as "σ". Standard deviation of the sample is represented as "s".

$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Sx stands for standard deviation of the sample.
xi is the value of each variable in the data set.
x bar represents the mean.
n is the total sample size.
And Σ stands for summation i.e. it says that we need to take the sum of "xi – x bar" for all values of x.

VARIANCE:

Variance is defined as the square of standard deviation. Variance of the population is represented as σ times σ. Variance for the sample is represented as "times".

$$s_x^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

Sx stands for standard deviation of the sample.
xi is the value of each variable in the data set.
x bar represents the mean.
n is the total sample size.
And Σ stands for summation i.e. it says that we need to take the sum of "xi – x bar" for all values of x.

RANGE:
Range is defined as the difference between largest value in a data set and the smallest value in a data set.

$$Range = Value_{Max} - Value_{Min}$$

ValueMax stands for the highest (maximum) value in the data set and ValueMin stands for the lowest (minimum) value in the data set.

Aim

- ✓ To decrease the time required for completing construction activity by proper decision-making throughout the construction process.
- ✓ To find the factor of delays in construction of emergency services and to overcome cost with advance construction technology.

Objectives

- ✓ To evaluate the metro project delay factors based on the interview, questionnaire & Case Study through various programs. This includes identifying different parameters for delay & cost overruns in view of respondents & comparing them. Evaluate the impact of advance technology to improve construction activities that relate to time.
- ✓ To study the delay impact on project, its mitigation measures and recommendations to further metro projects.
- ✓ To study cost-benefit analysis process through pune Metro project.

Research Methodology

Figure: Flow of Methodology

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."

DATA COLLECTION

By reading guideline I observed that because of delays in releasing of payment from the government agencies and sanctioning of material from the government engineers caused delay in construction activity.

By operating advance technology at construction project reduce delay in transporting of material and increase efficiency of work that ultimately reflect of time and cost.
From literature found that because of frequent change of project managers, Appointment of staffs in the site who are not experienced and also Non sequential progress of works and that Work was not followed as per procedure instead it was followed as per availability of resources caused delays in construction project.

Miss out of few materials while quoting tender by the tendering department. Delay in planning of resources from tendering department. Requirement of materials for future use, not noticed by the site engineer; no stock yard available for storing materials leads to material wastage

Unavailability of adequately trained health workers and lack of experience in managing an unprecedented emergency; the pandemic and the confinement measures created a psychosocial burden for the population and, especially, the wellbeing of the health workforce.

The construction industry is the vehicle through which physical development is achieved, and this is truly the locomotive of the national economy. The more resources, engineering know-how, labor, materials, equipment, capital, and market exchange provided from within the national economy, the higher the extent of self- reliance. The increasing complexity of infrastructure projects and the environment, within which they are constructed, place greater demands on construction managers to deliver projects on time, within the planned budget and with high quality.

Therefore, improving construction efficiency by means of cost-effectiveness and timeliness would certainly contribute to cost savings for the country as a whole. Efforts directed to cost and time effectiveness were associated with managing time and cost.

It also aims to identify the main factors that lead to project delays and to suggest recommendations on how to overcome or mitigate effects of the problem. Data is gathered from responses from questionnaire survey and interviews with those involved in construction project.

The surveys and research findings indicate that delay incidents occur mainly during the construction phase of a project and one or more parties usually contribute to delay. This paper highlights the importance of having more experienced and capable construction managers as well as skilled labourers to enable the industry to develop at a faster rate either nationally or internationally.

A questionnaire and personal interviews have formed the basis of this research. Factor analysis and regression modelling were used to examine the significance of the delay factors. From the factor analysis, most critical factors of construction delay were identified as

- Lack of commitment;
- Inefficient site management;
- Poor site coordination;
- Improper planning;
- lack of clarity in project scope;
- lack of communication; and
- Sub-standard contract.

DATA ANALYSIS

Questionnaire Survey

- Among the many available methods in 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, in order 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 platform to a variety of respondent working around the construction projects.

PILOT SURVEY AND QUESTIONNAIRE REVISION

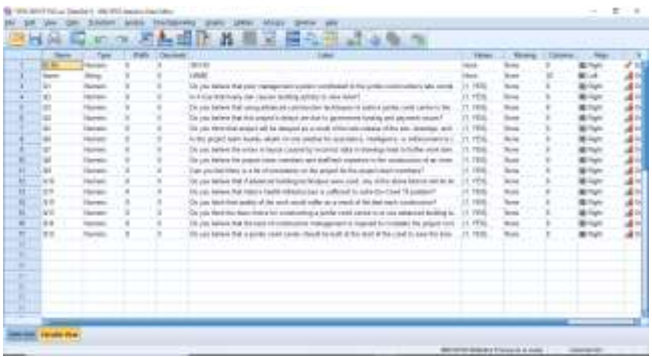
- To improve the questionnaire section, a pilot study was accompanied. This section contained identification of different causes, collection, and conclusions of data
- Questionnaires were sent to labourers, contractors, government employee, project managers, valuators and project engineers at metro project.
- To get more suitable and consistence meaning some factors should be rearranged.
- Some factors should be changed to give clearer importance and understanding. Better and 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.

SPSS SOFTWARE

Analysis of the questionnaires 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 Questionary Survey responses were reported in 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.

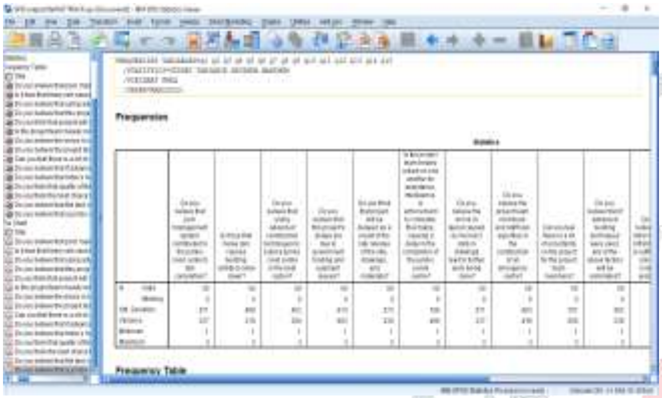


SPSS Data analysis

- 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.



RII Manual Method

- The sample for this study is relatively small. As a result, the analysis had combined all groups of respondents (clients, consultants, contractors and regulatory boards) in order to obtain significant results.
- Data was analysed by calculating frequencies and 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 categories generated from SPSS
- Data analysis was done calculating Relative Important Index (RII) by following formula.

$$\mathbf{RII = \Sigma W / A * N}$$

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

$$\sum W = 3 \times W_3 + 2 \times W_2 + 1 \times W_1$$

A = highest weight (i.e. 3)
N = total number of respondents (i.e. 100)

DATA COLLECTION & ANALYSIS

Case Study

PMRDA's Role

The Pune Metropolitan Region Development Authority (PMRDA) had proposed to take over the Metro project, which was declined by the PMC and PCMC. The opposing representatives said that the Metro rail is going to be implemented by Special Purpose Vehicle. Instead, the Corporations suggested inclusion of PMRDA in the SPV to increase the reach of the Metro rail.

Pune Metro project has been undertaken by MAHA Metro, a SPV (Special Purpose Vehicle) of Government of India and Government of Maharashtra. 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.

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.

Budget Allocations

For the financial year 2015-16, the Union government made an allocation of Rs 126.58 crores and the State government allocated Rs 174.99 crores. The budget allocation raised high hopes for the city's most awaited project but failed to keep the momentum, since apart from re-assurance nothing major happened that year. For the financial year 2016-17, the Union government made an allocation of Rs 10.2 crores and the State government allocated Rs 45 crores off the total 180 crores allocated for Pune and Nagpur metro projects. The citizens of Pune were disappointed with the budget, stating that the government had no interest in addressing Pune's needs. The opposition protested against the State government for side-lining Pune, and that the Nagpur metro was being carried out speedily while Pune project has not even started.

Plan:

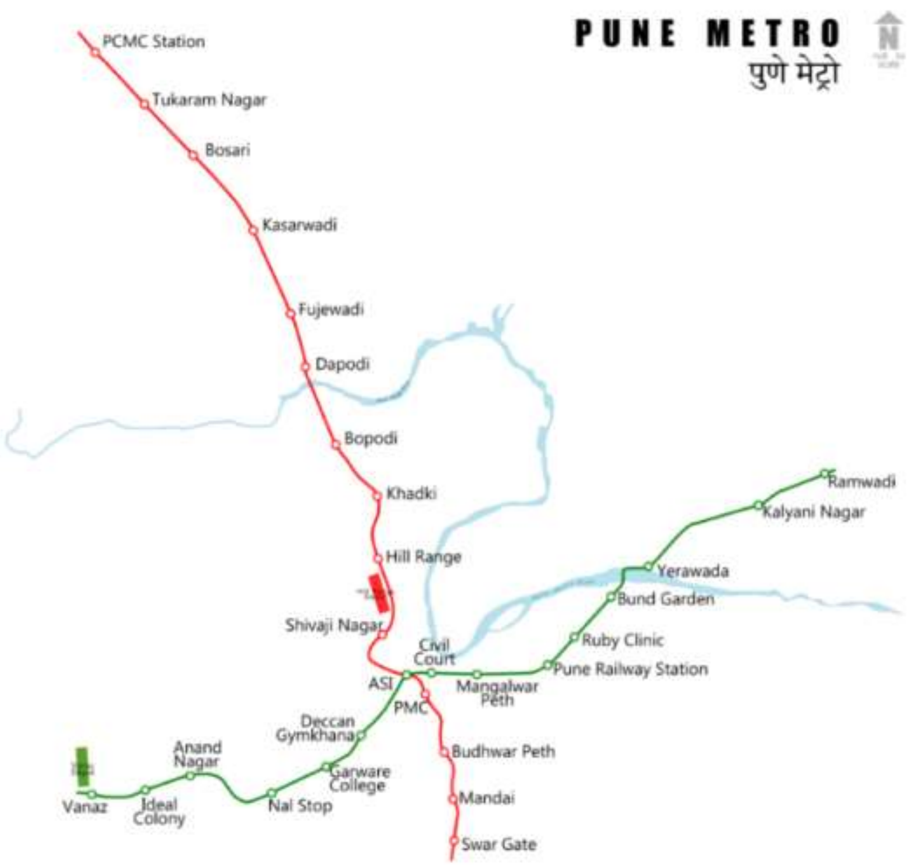


Figure1.2: Network Map of Pune Metro

Salient features

1. **Gauge (standard) - 1435 mm.**
2. **Route length (between dead ends) is as shown in Table**

Description	Underground (km)	Elevated (km)	Total (km)
Corridor-1: PCMC - SWARGATE	5.019	11.570	16.589
Corridor-2 : VANAZ - RAMVADI	NIL	14.925	14.925
		Total	31.515

3. Number Of Stations are as shown in Table

Description	Underground	Elevated	Total
Corridor-1: PCMC - SWARGATE	6	9	15
Corridor-2 : VANAZ - RAMVADI	NIL	15	15

4. Construction methodology

Elevated viaduct consisting pre stressed concrete "Box" shaped Girders on Single pier with pile / Open foundations, and underground section with Tunnel Boring and station in underground station cut and cover.

5. Total estimated cost (At August 2014 prices) without taxes

Corridor I - Rs.5320 Crore
Corridor II - Rs.2532Crore
Total - Rs.7852 Crore

6. Total estimated completion cost (with central taxes)

Corridor I - Rs.7422Crore
Corridor II - Rs.3447Crore
Total - Rs.10869 Crore

7. Funding pattern under (with Taxes & Duties) is as shown in Table no. 3

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
Equity By GOI	1351.00	13.43%
Equity By GOM	1351.00	13.43%
SD for CT by GOM (50%)	661.00	6.57%
SD for CT by GOI (50%)	661.00	6.57%
PTA against JICA Loan @ 1.40% PA	4665.00	46.38%
Loan from Financial Institution @ 12% PA	1341.50	13.34%
Total	10059.00	100.00%
SD by GOM State Taxes	279.00	
Subordinate Debts for Land (810 Cr) & For State Taxes (Rs 307 Cr) From ULB	1117.00	
Total	11455.00	
Interest during Construction (IDC)	109.00 238.00	JICA Loan @ 1.40% Market Borrowings @ 12%
Grand Total	11802.00	

8. Need for metro

Public Transport System is an efficient user of space and with reduced level of air and noise pollution. As the population of a city grows, share of public transport, whether road or rail based, should increase. Experience has shown that, in cities like Pune where roads do not have adequate width and which cater to mixed traffic conditions comprising slow and fast moving vehicles, road transport can optimally carry 8,000 persons per hour per direction (phpdt). When traffic density increases beyond this level, average speed of vehicles comes down, journey time increases, air population goes up and commuters are put to increased level, of inconvenience. Thus when on a corridor, traffic density during peak hours crosses this figure, provision of rail-based mass transport, i.e. Metro system should be considered.

✓ **Pune Metro Under Construction Lines (Phase 1 + Line-3)**

- Line-1 (Purple Line): Pimpri Chinchwad Municipal Corporation (PCMC) – Swargate
- Length: 16.589 km
- Type: Elevated & Underground
- Elevated: PCMC – Range Hills Ramp: 11.570 km, 9 stations
- Underground: Range Hills Ramp – Swargate: 5.019 km, 6 stations
- Depot: Range Hills (13.27 hectares)
- Number of Stations: 14

- Station Names: PCMC, Tukaram Nagar, Bhosari, Kasarwadi, Fugewadi, Dapodi, Bopodi, Khadki, Range Hill, Shivaji Nagar, Civil Court, Budhwar Peth, Mandai, Swargate

✓ **Line-2 (Aqua Line): Vanaz – Ramwadi**

- Length: 14.665 km
- Type: Elevated
- Depot: Hill View Depot at Kothrud (12 hectares)
- Number of Stations: 16
- Station Names: Vanaz, Anand Nagar, Ideal Colony, Nal Stop, Garware College, Deccan Gymkhana, Sambhaji Park, PMC, Civil Court, Mangalwar Peth, Pune Railway Station, Ruby Clinic, Bund Garden, Yerawada, Kalyani Nagar, Ramwadi

✓ **Line-3: Hinjawadi – Civil Court**

- Length: 23.33 km
- Type: Elevated
- Depot: Maan Village (20 hectares)
- Number of Stations: 23
- Station Names: Megapolis Circle, Embassy Quadron Business Park, Dohler, Infosys Phase II, Wipro Phase II, Pall India, Shivaji Chowk, Hinjewadi, Wakad Chowk, Balewadi Stadium, NICMAR, Ram Nagar, Laxmi Nagar, Balewadi Phata, Baner Gaon, Baner, Krushi Anusadhan, Sakal Nagar, University, R.B.I., Agriculture College, Shivaji Nagar and Civil Court

✓ **Pune Metro Proposed Lines Line-1 (Purple Line): Pimpri Chinchwad Municipal Corporation (PCMC) – Nigdi**

- Length: 4.41 km
- Type: Elevated
- Number of Stations: 3
- Station Names: Chinchwad, Akurdi, Nigdi Line-1 Extension (Purple Line): Swargate – Katraj
- Length: 5.464 km
- Note: The Detailed Project Report (DPR) for PCMC – Swargate Line-1's extension to Katraj suggests a 5.464 km underground route to be built with an estimated cost of Rs 4283.72 cr. Three new stations are proposed at Pushmangal Chowk, Shankar Maharaj Mutt and Rajiv Gandhi Zoological Park. These could alternately be built at Gultekadi, Saibaba Nagar and Katraj.

✓ Line-3 Extension: Shivaji Nagar – Kadam Wakwasti

- Length: 18 km
- Note: Delhi Metro Rail Corporation (DMRC) is currently preparing a detailed project report (DPR) for extending the Hinjawadi – Shivaji Nagar Line-3 by 18 km to Loni Railway Station (Kadam Wasti Grampanchayat) in eastern Pune

✓ Line-4: Swargate – Pul Gate

- Length: 3 km
- Note: Delhi Metro Rail Corporation (DMRC) is currently preparing a detailed project report (DPR) for this short new line

Figure1.3: Route Map of Pune Metro Project

Figure1.4: Status Report 1

Figure1.5: Status Report 2

Figure1.6: Status Report 3

Figure1.7: Status Report 4

Result Analysis

- **Cost of Land:** Govt land required for the project shall be given as grant by the State Government. Cost of private land has been added to the project and included as government equity but efforts shall be made to meet this cost through TDR and higher FARs.

- **Exchange Rate Fluctuation Risk-** As adopted for Phase-I and Phase-II of Delhi Metro and recently approved Phase III of Delhi Metro, it is assumed that exchange rate fluctuation risk on the repayment of JICA loan shall be borne in equal proportion by the equity holders, GOI & GOM.

- **Payment of Dividend-** As adopted for Phase-I & Phase-II of Delhi Metro, this metro corridor of Mumbai MRTS shall be exempted from the payment of dividend on equity till the senior debt has been fully repaid. The total completion cost of the project including IDC and excluding govt land works out to Rs 217,523 Million. The funding for the same shall be as under:

- **Government Contribution –** GOI & GOM will contribute a total equity of Rs 64,343 Million which is 30% of the total completion cost. This means that both GOI and GOM will share 15% of the total cost amounting to Rs 32,172 Million.

- **JICA Loan –** JICA funding of 60 % of total completion cost excluding taxes, duties and land cost, works out to 48% of the total completion cost including land and taxes and amounts to Rs 104,647 million as loan.

- **Subordinate Debt:** To pay back state and central taxes and duties amounting to which is of the total completion cost of the project, interest free Subordinate Debt from GOI and GOM is considered. It includes which can be waived off by the City agencies as the project is for the benefit of the City. The payment of this loan will be after the payment of loan.

- **Stake holder Contribution:** The cost of stations falling in the areas belonging to MIAL (Mumbai International Airport Authority & ASIDE (Assistance to States for Infrastructure Development for Export Promotion) will be borne by them. Total 5 stations fall in their area and cost of the stations amounting to is proposed to be contributed by these agencies as stake holder contribution. Figure No.4 Financing Pattern (Source- MMRC)

- With above funding pattern, the project generates positive cash flows during the analysis period of 44 years. But once the payment of loan starts the project has negative cash flows for and the project is not able to meets its loan obligations.

5.2 Calculation of value of lost time in work zone

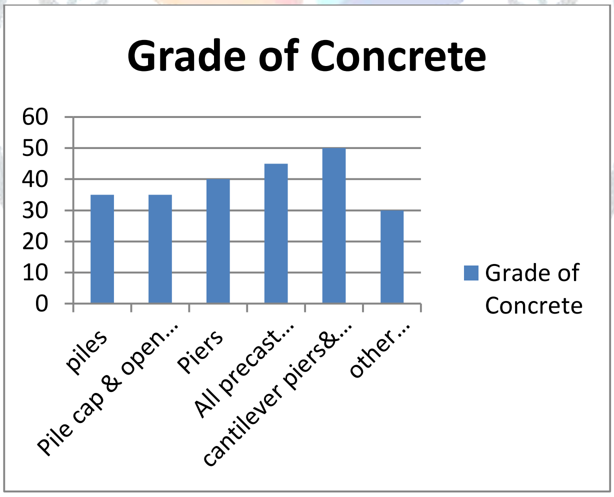
- Pune has seen colossal modern development amid the most recent 10 years. Quick urbanization in the on-going past has put the movement framework to push. With countless have come up both in little scale just as in substantial and medium scale industry, and so on traffic in the city is required to shoot 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

Station Construction

It is proposed to develop the raised concourse over the street at a large portion of the areas to limit arrive obtaining. To keep the rail level low, it is proposed not to take viaduct through the stations. Consequently a different basic design is required (in spite of the fact that this may require the break in the starting operational at each station areas. Substructure for the station bit will likewise be like that of viaduct and will be completed a similar way. In any case, there will be single viaduct section in the station territory, which will be situated on the middle and supporting the concourse braces by a cantilever arm in order to dispose of the segment on option to proceed.

Table: Components

Sr. No.	Components	Grade of Concrete
1	Piles	M-35
2	Pile cap & Open foundation	M-35
3	Piers	M-40
4	All Precast element for viaduct & Station	M-45
5	Cantilever Piers & Portals	M-45 to M-60
6	Other Miscellaneous Structure	M-30

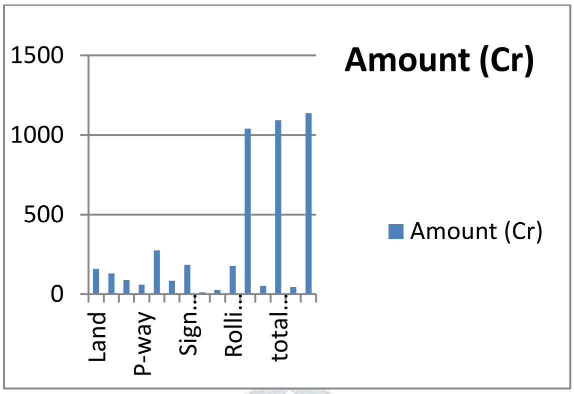


Graph1.2: Grade of Concrete

Table: Cost Estimation Table

Sr. No.	Item	Unit	Amount
1	Land	Km	158.38
2	Station Buildings		130.85
3	Depot		88.25
4	P-way		60.17
5	Alignment & Foundation		275.64
6	Power Supply		85
7	Signaling & telecom		185.25
8	Capital expenditure on Security		12.58
9	Utilities, road works & Other Civil works	r. km	25.85
10	Rolling Stocks	Each	177
11	Total qty (Expect land)		1040.59

12	General Charges include design charges		51.72
13	Total of all items (Except Land)		1092.31
14	Contingencies 4%		43.69
15	Gross Total		1136



Graph: Cost Estimation

Planning & Design Criteria for Station

- The station can be isolated into open and non-open regions (those zones where get to is confined). The general population region can be additionally subdivided into paid and unpaid zones.

- The stage level at raised stations is controlled by a basic freedom of 5.5 m under the concourse over the street convergence, permitting 3.5 m for the concourse tallness, over 1 m for concourse floor and 1.5 m for structure of tracks over the concourse. Further, the stages are 1.09 m over the tracks. This would make the rail level in a lifted circumstance at any rate 12.5 over the ground.

- In the underground stations, stage level is dictated by a basic freedom of 2.50m over the station box, which would be 13.7 m high. Permitting around 80 cm for the container structure, 70 cm for rails/supporting structure and 1.09nm for rail to stage height, would make the stages in an underground circumstance in any event 13.5 m subterranean.

- The concourse contains programmed admission gathering framework in a way that separates the concourse into unmistakable zones. The 'unpaid region' is the place travelers access the framework, get travel data and buy tickets. On-going through the ticket.

- The game plan of the concourse is surveyed on a station-by-station premise and is dictated by site limitations and traveler gets to necessities. In any case, it is arranged so that most extreme observation can be accomplished at greatest reconnaissance can be accomplished by the ticket lobby chief over ticket machines, programmed passage gathering (AFC) gates, stairs and elevators. Ticket machines and AFC entryways are situated to limit cross streams of travellers and give satisfactory dissemination space.

- Sufficient space for lining and traveler stream has been permitted at the ticketing doors. 8. Station passages are situated with specific reference to traveller catchment focuses and physical site imperatives inside the option to proceed distributed to the MRTS.

- Office convenience, operational region plant room space is required in the non-open zones at each station.

- The DG set, bore well siphon house and ground tank would be found by and large in one zone on ground

- The system is being designed to maximize its attraction to potential passengers & the following criteria have been observed.

- Minimum distance of travel to & form the platform & between platforms for transfer between lines. Adequate capacity for passenger movements. Convenience, including good signage relating to circulation & orientation. Safety & security including a high level protection against accidents.

- Minimum capital cost is incurred consistent with maximizing passenger attraction.

- The numbers & size of staircase/escalators are determined by checking the capacity against AM & PM peak flow rate for both normal & emergency conditions such as delayed train service, fire etc.

- Passenger handling facilities comprise of stairs/escalators, lifts & tickets gates required to process the peak traffic from streets to platforms & vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

Pune has witnessed massive modernization in the last decade. Rapid urbanization in the past pushed the movement framework. With so many small and large businesses popping up, the city's traffic is certain to increase. Pune's traffic demands cannot be handled by a street-based framework.
The current street-based urban transport system in Pune is under strain, resulting in longer journey times, increased air pollution, and increased street accidents. With an estimated increase in the city's population, upgrading and expanding transportation infrastructure is vital. So a rail-based Metro system in the city has been suggested.
In addition to the project's beneficial environmental impacts (such as reducing gridlock during rush hour), the project has certain negative environmental impacts (due to the project's usage period) for which an Environmental Management Plan has been created.
The task should be completed using an SPV on DMRC funding design.
It has been appraised based on the Delhi Metro tolls chosen by the charge obsession council in 2009, raising the equivalent for 2018. To analyze the task's return, the tolls have been updated every second year by 12%.

Method of construction and type of materials used

At locations where pollution level has already exceeded the permitted level or is on higher side, every construction activity needs very close scrutiny to ensure that there is no further environmental degradation. Planning for method of construction and type of materials used plays a very vital part in containing the adverse environmental impact which is clear from a few following examples. Maximising use of 'precast' concrete structural members will provide a big relief from adverse environmental impact. In an elevated metro construction, by using latest techniques and high capacity cranes, all the members of super structure, even the columns and pier head can be precast, thus reducing the adverse environmental impact specially SPM and noise pollution by 20% to 30%.

Use of high strength concrete to optimum level will substantially reduce not only transportation and erection cost but will also mitigate pollution. Similarly, by appropriate use of 'pre-stressing' in concrete structure, economy is invariably achieved as there is reduction in volume from 20% to 40% in most of the cases, which in turn results in a positive impact on environment during construction. The technique reduces the weight and volume of structure thus correspondingly reducing pollution in transporting, assembly, manufacture, etc.

In 'cut and cover' method of construction for underground metro, designing 'diaphragm wall' as a permanent structural member instead of only a temporary structural member will reduce volume of excavation transporting of spoil and quantity of concreting. With availability of better quality of water proofing chemicals rubber metal water stoppers along with advanced techniques of construction; the structure so designed will prove to be environment friendly as well as economical also. Even the environmental damage due to construction of temporary diaphragm walls can mostly be reduced by using of steel sheet piles driven by modern 'vibrohammers' which are powered by 'noiseless' and 'green' power packs for the locations where suitable soil strata exists. This has been followed in Delhi Metro near the Old Secretariate and Delhi University (an historical building area) and it is resulting in desired improvement. Even the use of "Jack Down Method" for well sinking will be a positive step towards reducing pollution as it will reduce the construction period, deployment of cranes to handle the kantalage, trucks for transporting etc
As the transportation of 'spoils' to dumping area and movement of precast or ready mix concrete is a major transportation activity to be carried out for a considerably long duration, use of 'battery operated' truck is an excellent environment friendly option which planners must look into while finalizing transportation scheme as it will alone reduce burden of pollution as generated from plying of thousands of trucks per day for construction of underground metro.

Similarly electrically operated crane hoists wherever possible should be given preference. As in several developing countries, there is shortage of electricity in cities, to complete the construction activity remain as to be dependent on 'diesel generators', therefore, the need for maximizing the use of electrical energy in place of fossil energy right from the planning stage needs special mentioning.
Environmentally sensitive locations, the older diesel operated machineries should not be allowed to be used and the same should better be a contract condition for construction itself.

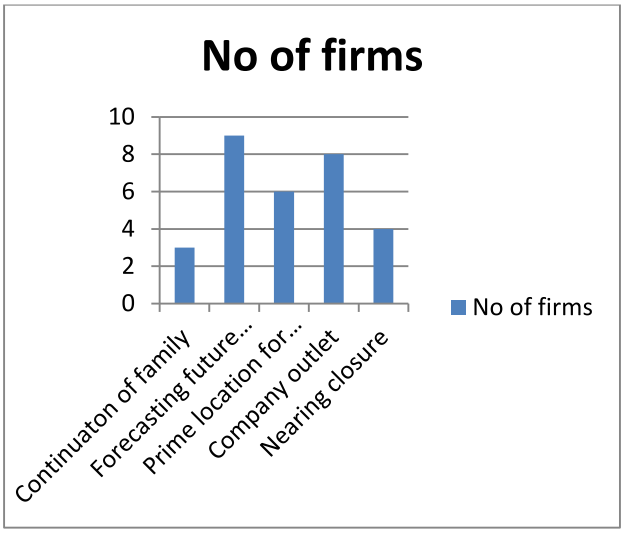
Use of durable materials and structures would obviate the need for frequent repair and replacement, which would again lessen the burden on environmental resources. On a green road such as Mall Road in Delhi, cutting of long rows of fully grown green tall trees along the under-ground alignment could be avoided by judiciously reducing the width of digging for construction in a 'cut-cover' stretch by replacing outside extension of bottom slabs of the box by providing piles below the box to counter buoyancy. Such innovative method of construction keeping the site condition in view will always give opportunity of reducing avoidable increase in pollution.

The availability of versatile and powerful machines for 'trenchless' laying of pipes and cables is also helping in long way to contain the pollution in sensitive locations of the city. The use of longer length of temporary 'liners' in construction of pile foundation to avoid use of Bentonite from environment point of view must be adopted in such environmentally sensitive location and minor economic consideration should not come in the way of such decisions. Some of the latest pile driving machineries are equipped to have full length temporary liners in the pile foundation construction which has been deployed in Delhi Metro Rail Project especially in sensitive areas.

Reason for maintaining business establishments

The Metro rail construction also caused for numerous hazards and problems directly or indirectly related with their business and life. These include traffic related issues, issues regarding vehicle parking, compulsion to reduce the work force etc. 24% percentage of the respondents had health related issues due to dust. Another major issue is with regard to the cutting down of working staff. As the business transaction was lowered many of the establishments became ‘over-staffed’. The burden of maintaining staff was a hectic problem which has got financial, emotional and social dimensions. 12% percent of the firms curtailed their staff thereby many of them thrown out of employment became jobless unexpectedly not due to their work inefficiency but a reason no way connected with them- the Metro work.

Reason for maintenance	Number of Firms	Percentage
Continuation of Family Business	3	10%
Forecasting future benefits	9	30%
Prime location for Business	6	20%
Company Outlet	8	26.6%
Nearing Closure	4	13.33 %
Total	30	100%



30% percent of them maintained their shops with the optimistic belief that their business transaction would flourish once the metro work is over. The company outlet establishments did not face much crisis. A few of them have sentimental reason for continuing the business as it is their family business. There were many shops stopped their business operations and in our study 13% were on the verge of closing them down.

Methodological Problems

The methodological problems in DPR submitted by DMRC are listed below. 1. DMRC commissioned a report from IIT Bombay to project ridership along potential of metro rail corridors (IIT Bombay, 2008). To do this, IIT Bombay used a 'stated preference survey' asking citizens for their preferred mode of public transport from among various alternatives. Surveys were carefully designed as it can introduce a bias in a respondent's answer. But the IIT Bombay survey used a leaflet, states that Pune's metro will provide "cost of travel comparable to bus fare, trains will run at convenient frequency of 3 min during peak hours and comfortable sitting in A/C environment".

None of these claims holds true in the DPR. Therefore, the ridership figures were estimated from a deeply flawed consumer survey, which advertised a service that was very different from the service that was actually designed.

The commuter survey also asked respondents to choose between the proposed metro rail and current frequencies and capacities of existing modes. This ignores the possibility that frequencies and performances of both the existing bus system and suburban rail system can be significantly improved at a fraction of the cost and time required for the metro rail. In other words, the metro travel demand was forecasted by comparing an ideal yet to be implemented metro rail with the current state of other neglected and under-funded public transport services.

Public transport modes such as the metro rail are considered desirable because they can win people away from private vehicles. For this, various public transport modes must complement each other and not compete. But, the DPR is silent about integrating the metro rail with other public transport modes. In fact, the two proposed corridors compete with the proposed BRT and existing suburban rail along their entire length. In addition to these methodological errors, the report also contains many data anomalies and inconsistencies which raise more questions about the DPR

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 considered in the DPR are the capital and operational costs, while societal benefits are said to arise from various categories such as savings in time, fuel, 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 flawed. The DPR estimates total benefits to society from the metro rail in 3 horizon years – 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 conservative 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.

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 only time saved in travel but also the walking and waiting time for one's transport and money/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 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.

Benefit Comparison

The different possible ridership scenarios for the proposed metro rail and estimate likely benefits in 2011 are compared against the benefits claimed by the DPR.

Each scenario represents a particular combination of shifts from buses, two wheelers and cars to metro rail and benefits under these scenarios are calculated using the DPR's methodology in spite of reservations about it. Figure presents the benefit under different scenarios. The DMRC scenario represents the benefit claimed in the DPR.

Based on the presented cost and benefit flows, the DPR concludes that the proposed project has an overall socioeconomic return of about +5% at a 12% discount rate, and hence it is good for the city. Figure 2 shows the socioeconomic NPV of the metro rail (also at 12% discount rate) using our benefit estimates and the costs given in the DPR under different scenarios. As can be seen, the proposed metro rail has a negative socioeconomic NPV in all scenarios in spite of conservative assumptions. Issues such as not achieving the projected ridership as seems likely are not considered (Mohan, 2008). This raises serious questions about the DPR and implementation of the proposed metro rail for Pune.

Site Visit Photo

Rank	Barriers	Mean	SD	LoB
1	Lack of a well-design reward system	2.674	0.778	3
2	Misleading QMS purposes	2.442	0.666	2
3	Uncertainty with sub-contractors and supplier quality systems	2.233	0.782	2
4	Lack of effective internal communication	2.209	0.833	2
5	ISO 9001is a matter of fulfilling audit requirements	2.186	0.907	2
6	Lack of effective management response	2.140	0.676	2
7	Lack of strong motivation	2.116	0.625	2
8	Lack of corporate commitment	2.070	0.856	2
9	Resistance to QMS implementation	2	0.756	2
10	Failure in disseminating QMS	1.977	0.707	2
11	Lack of funding for QMS implementation	1.977	0.740	2
12	ISO 9001 is a documentation matter instead of opportunity to make a change	1.907	0.684	2
13	Difficulty in understanding terminology	1.884	0.586	2
14	Poor external communication	1.884	0.731	2
	Total	2.121	0.766	2

SURVEY QUESTIONS

General

1. Name
2. Email
3. Your position
4. Phone number
5. Do you think metro is necessary service required in Pune?
6. Will the amount of loan for the funding of project is adequate?
7. Will the population of constructing area is main factor to decide location of metro station?
8. Is metro project affecting the overall environmental impact?
9. Do you think that project will be delayed as a result of the late release of the site, drawings, and materials?
10. Is the project team heavily reliant on one another for assistance, intelligence, or enforcement to complete their tasks, causing a delay in the constructing metro rail project?
11. Do you believe the errors in layout caused by incorrect data in drawings lead to further work being done?
12. Do you believe the project team members and staff lack expertise in the construction of an metro rail Project?
13. Can you feel there is a lot of uncertainty on the project for the project team members
14. Due to traffic on main road line affect the delaying in construction of metro?
15. Is improper labour management affect delaying of metro project?
16. Will current speed of metro construction complete the project within time?
17. Is delay in project will impact on total project cost?
18. Does precast bridge deck increase the cost of project?
19. Is improper material management affect delaying of metro project?
20. Do you think metro rail reduces road traffic in Pune?
21. Will the land acquisition of area is main factor to delaying construction of project?
22. Do you think that project will be delayed as a result of the late release of the site, drawings, and materials
23. Is insufficient machinery, manpower management affect delaying of metro project?
24. Due to lockdown in Pune affect the delaying in construction of metro rail project?

Relative Index Method Results

Sr.No.	Questions	YES(N1)	No(N2)	CAN'T SAY(N3)	Total
1	Do you think metro is necessary service required in Pune?	84	11	5	100
2	Will the amount of JICA loan for the funding of project is	65	24	11	100
3	Will the population of constructing area is main factor to decide	76	17	7	100
4	Is metro project affecting the overall environmental impact?	83	13	4	100
5	Do you think that project will be delayed as a result of the late release of the site, drawings, and materials?	82	11	7	100
6	Is the project team heavily reliant on one another for assistance, intelligence, or enforcement to complete their tasks, causing a delay in the constructing metro rail project?	82	11	7	100
7	Do you believe the errors in layout caused by incorrect data in drawings lead to further work being done?	86	11	3	100
8	Do you believe the project team members and staff lack expertise in the construction of an metro rail project?	80	16	4	100
9	Can you feel there is a lot of uncertainty on the project for the project team members?	87	7	6	100
10	Due to traffic on main road line affect the delaying in	81	10	9	100
11	Is improper labour management affect delaying of metro	79	14	7	100
12	Will current speed of metro construction complete the project	88	6	6	100
13	Is delay in project will impact on total project cost?	81	11	8	100
14	Does precast bridge deck increase the cost of project?	77	14	9	100
15	Is improper material management affect delaying of metro	97	3	0	100
16	Do you think metro rail reduces road traffic in Pune?	85	10	5	100
17	Will the land acquisition of areas is main factor to delaying	81	15	4	100
18	Do you think that project will be delayed as a result of the late release of the site, drawings, and materials	88	6	6	100
19	Is insufficient machinery, manpower management affect delaying of metro project?	77	9	14	100
20	Due to lockdown in pune affect the delaying in construction of metro rail project?	79	15	6	100

Sr.No.	Questions	YES(1)	No(2)	Other(3)	Total	Total Number(N)	A×N	RII	Ranks
1	Q1	84	22	15	121	100	300	0.4	3
2	Q2	65	48	33	146	100	300	0.49	9
3	Q3	76	34	21	131	100	300	0.44	7
4	Q4	83	26	12	121	100	300	0.4	3
5	Q5	82	22	21	125	100	300	0.42	5
6	Q6	82	22	21	125	100	300	0.42	5
7	Q7	86	22	9	117	100	300	0.39	2
8	Q8	80	32	12	124	100	300	0.41	4
9	Q9	87	14	18	119	100	300	0.4	3
10	Q10	81	20	27	128	100	300	0.43	6
11	Q11	79	28	21	128	100	300	0.43	6
12	Q12	88	12	18	118	100	300	0.39	2
13	Q13	81	22	24	127	100	300	0.42	5
14	Q14	77	28	27	132	100	300	0.44	7
1	Q1	97	6	0	103	100	300	0.34	1
2	Q2	85	20	15	120	100	300	0.4	3
3	Q3	81	30	12	123	100	300	0.41	4
4	Q4	88	12	18	118	100	300	0.39	2
5	Q5	77	18	42	137	100	300	0.46	8
6	Q6	79	30	18	127	100	300	0.42	5

8 Recommendation from survey

- Metro rail projects are helpful in augmentation of public transport infrastructure. These projects are frequently characterized by time and cost overruns.
- The aspect of time overrun is undertaken for investigation in this research. Progress of a metro rail project is typically influenced by multiple impediments.
- These impediments can be an outcome of factors related to owner, contractor, consultant, materials issues, labour issues, technology related aspects and external agents.
- A systematic evaluation of the causes of delay is expected to identify the project delay factors in the overall planning, construction and commissioning phases of a project.
- The paper presents the results of a study on the identification of critical delay factors, their importance, and ranking for the case of metro rail projects in Pune.
- Based on a total of factors, a questionnaire was designed to gather the opinion of professionals with experience in rail based projects.
- Data from the survey was analysed using the Relative Importance Index (RII) and factors of delay were ranked.
- RII represented the degree of importance assigned to the factors of delay.
- The RII of factors suggests that

Sr.no	Questions	RII	Rank
1	Do you think metro is necessary service required in Pune?	**0.4**	**3**
2	Will the amount of JICA loan for the funding of project is adequate?	**0.49**	**9**
3	Will the population of constructing area is main factor to decide location of metro station?	**0.44**	**7**
4	Is metro project affecting the overall environmental impact?	**0.4**	**3**
5	Do you think that project will be delayed as a result of the late release of the site, drawings, and materials?	**0.42**	**5**
6	Is the project team heavily reliant on one another for assistance, intelligence, or enforcement to complete their tasks, causing a delay in the constructing metro rail project?	**0.42**	**5**
7	Do you believe the errors in layout caused by incorrect data in drawings lead to further work being done?	**0.39**	**2**
8	Do you believe the project team members and staff lack expertise in the construction of an metro rail project?	**0.41**	**4**
9	Can you feel there is a lot of uncertainty on the project for the project team members?	**0.4**	**3**
10	Due to traffic on main road line affect the delaying in construction of metro?	**0.43**	**6**
11	Is improper labour management affect delaying of metro project?	**0.43**	**6**
12	Will current speed of metro construction complete the project within time?	**0.39**	**2**

13	Is delay in project will impact on total project cost?	**0.42**	**5**
14	Does precast bridge deck increase the cost of project?	**0.44**	**7**
15	Is improper material management affect delaying of metro project?	**0.34**	**1**
16	Do you think metro rail reduces road traffic in Pune?	**0.4**	**3**
17	Will the land acquisition of area is main factor to delaying construction of project?	**0.41**	**4**
18	Do you think that project will be delayed as a result of the late release of the site, drawings, and materials	**0.39**	**2**
19	Is insufficient machinery, manpower management affect delaying of metro project?	**0.46**	**8**
20	Due to lockdown in pune affect the delaying in construction of metro rail project?	**0.42**	**5**

Main Findings: The study concluded in identification of 5 most critical delay-factors from a list of Factors shortlisted factors.. The identified factors included:
(1) Improper material management,
(2) The late release of the site, drawings, and materials,
(3) Scope change,
(4) Delay in land acquisition,
(5) Improper labour management,

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

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

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

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

CONCLUSION

- ✓ To develop a good risk database with the right software where the right features such as relational triggers and constraints, key-word usage, tables and indexes should be chosen and carefully incorporated during the process of encoding is performed.
- ✓ With increasing speeds, the emission of micro-pressure waves from tunnel portals, when high-speed at the opposite side, can contribute significantly to the annoyance of residences near a high-speed line
- ✓ Construction of station and tunnels is located as per require of public as well as other geological techniques and design. Government has deployed effective funding pattern to finance; hence profits can be ripened after the completion of the project
- ✓ We also studied economic, environmental and social attributes, while the factors which stimulate the rail use, through the passengers' satisfaction.
- ✓ Benefits to Public for comfortable, economic and secure travel, connecting unconnected areas, decongestion of roads along with Social, Economic and many environment and benefits. This study has involved various civil engineering concepts which is used in practical fields.
- ✓ The development such metro projects would boost the infrastructure and help the economy to develop.
- ✓ Studied the different Risk factors and analysis process for the Metro construction
- ✓ Construction and operation of long tunnels for high-speed rail by examining others that have already been completed & that can be planned and executed in a way such that the experiences and bottlenecks identified in previous projects can be eliminated
- ✓ Improvement initiatives on going and/or completed
- ✓ Quality failures e.g. cost of production failures per month
- ✓ Percentage on-time delivery to customer
- ✓ Failure costs per development project as % of project costs
- ✓ Controlled documents overdue for review
- ✓ Internal audit observation trends
- ✓ Customer complaints (numbers, response times)
- ✓ Recalls and other market withdrawals
- ✓ Process deviation frequency
- ✓ Staff training status
- ✓ Equipment breakdowns per month

RECOMMENDATIONS TO FURTHER METRO PROJECTS

- The choice of underground vs. aboveground for urban mass transit systems must be made by each city considering each area of the transit system, based on its own specific circumstances.
- Few cities, which have had Metro systems in use for substantial time regret the choice to build that system and, in general, to place it underground near and adjacent to the city center.
- The above statement, and the economic cost environment which supports it, should be documented and publicized to assist decision-makers in making choices for new Metro systems.

- Cities and transit agencies that undertake specific studies of the relative advantages and disadvantages of underground transit alignments, especially those including long-term cost benefit information are encouraged to publish their analyses and findings for the benefit of other decision makers around the world.
- The critical decision between an underground and an aboveground alignment in many cases is strongly, if not completely, influenced by the issue of perceived high initial capital cost.
- This decision should, however, consider the benefits of increased long-term social and environmental improvements and beneficial economic development.
- Representative decisions for specific mass transit systems should be documented and illustrated by reference to current and retrospective studies of typical projects (including those older than 20 years), considering all costs and benefits, real and perceived.
- Estimates of changes in land value and perceptions in changes in environmental conditions close to alignments and, quantified estimates of all the benefits that have accrued to the region because of the particular project, would be of particular interest road alignments would also be pertinent

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