

Study of Multi-Model Mass Rapid Transit System of Nagpur City

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Abstract - Public transportation systems include a variety of transit options such as buses, light rail, and subways. These systems are available to the general public, may require a fare and run at scheduled times. A metro system is a railway transport system in an urban area with a high capacity, frequency and the grade separation from other traffic. Nagpur Metro is a new multi-model mass rapid transport system (MMRTS) developed in Nagpur, Maharashtra, India. The MRTS covers a total length of 38.21 km and is estimated to cost Rs 86.80bn(\$1.4bn).The Nagpur Metro encompasses two alignments, which include the north-south corridor and the east-west corridor. In this paper we come to know the various the constructional aspect and various techniques used in construction of Nagpur metro rail also we go through the procedure of material used, casting, construction method of pier and girder. This paper also explores the various some unique features of Nagpur metro rail like construction ,feeder system and green metro taken into Nagpur metro rail.

Index Terms - Multi-Model Mass Rapid Transit System, Metro Rail, Nagpur Metro, finance, Green Metro.

I.INTRODUCTION

Multi-model Mass Rapid Transport System (MMRTS) may be defined as “Public ,ordinary networks in urban areas, particularly in metropolis where the citizen may utilize the combinations of several modes of transportation such as personal car ,taxi, two-wheeler, metro, bus, walking”. Using these networks brings real benefits for citizens by saving their time and cost, and also greatly assists sustainable development of metropolis. Multimodal public transportation (MMTS) has been welcomed as a sustainable alternative to car travel which is also

environmentally friendly and provides flexible mobility to the citizens. It adds a dimension to the public transport by providing it with ease of travel through its multimodal character. Multi-modal transportation place unique space-time limitation on travelers such as long access and egress stages, long trip times, transfers and limited system accessibility ,users of the system will be constrained in their activity engagement opportunities.

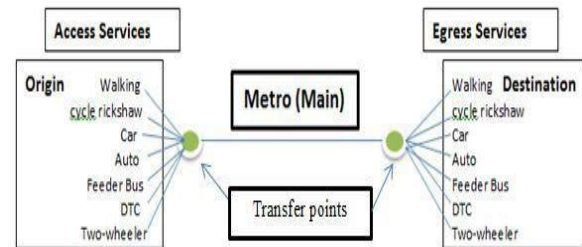


Fig 1: Schematic Outline of Multimodal Transport System (Metro as Main Mode)

Kolkata Metro is the first metro in India. The first metro service was inaugurated in Kolkata in 1984 by former Prime Minister Indira Gandhi. Delhi Metro was India's first modern metro which began its operation in 2002. Rapid Metro Rail Gurgaon, which started operations in November 2013, is India's first privately owned & operated metro. Nagpur is one of the prominent cities located in Central India in the state of Maharashtra. The city limits encompass an area of 217 Sq. Km, and the district is located on a Deccan Plateau. The city lies at the dead center of the country making it the geographical center of India. According to 2011 census the city has reached a population of 2.4 million with average density of 11,000 persons/ Sq. Km. Nagpur city is well connected with various kinds of Transportation modes from

different parts of the country. The city has a road network of around 1900 Km of which 500 Km accounts to major roads Nagpur Metro is an under construction rapid transit system for the city of Nagpur, India. Construction on the project began on 31 May 2015. The first trial run was conducted on a 5.6 km section between Mihan area and Khapri station on September 30. The project is initiated in 2015 and the first two phases are scheduled to be completed by 2023. The project aim to reduce average travel time of commuters by around 50 percent.

II. LITERATURE REVIEW

T. RAWAL “Integrated Multi-Modal Transportation In India”

Multi-modal commuting combines the benefits of walking, bicycle commuting or driving with the benefits of rapid transit while balancing some of the major disadvantages of each individual mode. The location play a large role in multi-modal commuting. When the commuter finds the distance between the origin and destination too far to be enjoyable or practical, commute by car or motorcycle to the station may remain practical, as long as last mile connectivity to destination is practical by walking, a bicycle, or shuttle/feeder bus. The biggest challenge for Indian cities would be to achieve the highest level of integration of multiple modes to shift the captive ridership of personalized transport to at least partial usage of public transport for mixed-mode travel. It is also important that utilization of multi-modal mass rapid transit system to its maximum capacity, depends on mobility of non-motorized vehicles and intermediate para transit.

A. SAO, “Nagpur Metro Rail: A review”

Nagpur Metro Rail System comprise with the following features:

- Greenest Metro
- Green Building
- Advance Project Management Technology (5D-BIM)
- Multi-Modal Mass Rapid Transit System (MMRTS)
- High quality and efficient feeder service
- Transit Oriented Development(TOD)
- Common Mobility card for Seamless travel

III. FINANCE FOR NAGPUR METRO PROJECT

The Nagpur Metro Rail Corporation (NMRC) has drawn funding from several channels at the state, Centre and international level for the Rs 8,860 crore project. The Nagpur Metro Rail project has received around 20 per cent funding from the Centre and an equal investment from the Maharashtra government, Nagpur Municipal Corporation provided around 5 per cent as did the Nagpur Improvement Trust. As much as Rs 4,000 core has come from German-government owned development bank KFW. Rs 600 crore has come from French development agency AFD.

IV. ALIGNMENT, ROUTS AND GEOMETRIC FEATURES OF NAGPUR METRO

4.1(a) Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On elevated sections minimum radius of 160 m has been used at one location having speed potential upto 40 km/h.

4.1(b) Transition Curves

Length of Transitions of Horizontal curves (m)
Minimum : 0.44 times actual cant or cant deficiency (in mm), whichever is higher. Minimum curve length between two transition curves: 25 m. Desirable : 0.72 times actual cant or cant deficiency, (in mm), whichever is higher.

4.1(c) Vertical Alignment

(i) Elevated Sections

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the ‘Box’ shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 13.5 m above the road level with concourse.

(ii) Gradients

Normally the stations shall be on level stretch. In limited cases, station may be on a grade of 0.1 %. Between stations, generally the grades may not be

steeper than 3.0 %. However, where existing road gradients are steeper than 2 %, or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

(iii) Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%.

4.2RAIL SECTION

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg. /m) rail section.

4.3ROUTE ALIGNMENT

Nagpur Metro Rail Project will consist of 41.700 Km metro corridor, 40 stations and 2 Depots First at near Khapri station for north –south corridor, second at near Lokmanya nagar for east west corridor. The entire stretch will be divided into 2 alignments or corridors as follows:

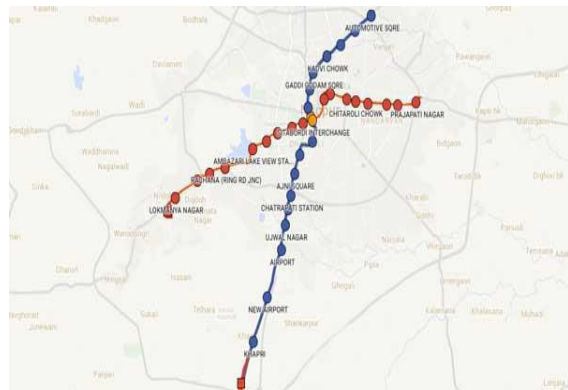


Fig. Alignment of Nagpur Metro



Fig.Route of Nagpur Metro North-South Corridor 1

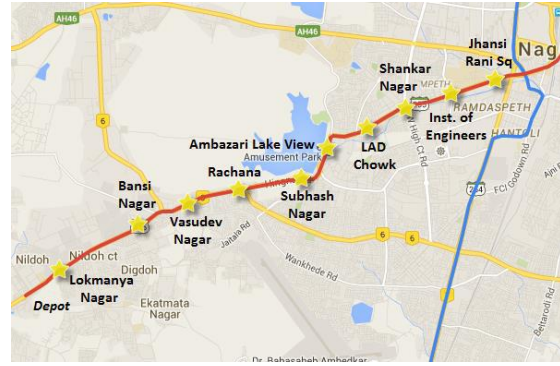


Fig. Route of Nagpur Metro East-West Corridor 2

4.4 Salient Feature

1. Gauge (standard) - 1435 mm
2. Max. Permissible speed - 80kmph
3. Voltage- 25 KV AC
4. Current Collection Overhead Current Collection System
5. SCADA system Provided
6. Train Composition 3- Car train: DMC+TC+ DMC
7. Seating Arrangement Longitudinal
8. Passenger Carrying Capacity (Crush @ 6 person/sq. m)

Particular	Seated	Standing	Total
DMC (Driving Motor Car)	43	204	247
TC/MC (Trailer Car)	50	220	270
3-CAR	136	628	764

Fig. Passenger Carrying Capacity

9. Axle load: 16T
10. Max Acceleration: 1.0 m/s2
11. Maximum Deceleration: 1.0 m/s2 (Normal Brake), > 1.3 m/s2 (Emergency Brake)
12. Maximum Design Speed: 95 kmph
13. Maximum Operating Speed: 85 kmph
14. Schedule Speed (as per train operation in following lines):

- a. Corridor I: North-South Corridor: 32-34 kmph
- b. Corridor II: East- West Corridor: 30 kmph

15. Signalling, telecommunication & train control
 - a. Type of signalling-Cab signalling and continuous automatic train Control with automatic train protection (ATP)
 - b. B) Telecommunication - I) integrated system with fibre optic cable, SCADA, train radio, PA system etc. II) Train information

system, control telephones and centralized clock system.

16. Fare collection- Automatic Fare collection system with POM and Smart card etc.

V.SUPERSTRUCTURE OF NAGPUR METRO RAIL

Superstructure that part of the structure which supports traffic .All the parts of the bridge which is mounted on a supporting system can be classified as a Super structure which includes pier, pier cap, bearings ,beam or girder.

5.1 Pier

Piers is raised structure typically supported by a well-spaced piles piers can range in size .The height of pier used in metro is 8.971m.The purpose of the pier is to support the segments. Concrete *IRMC* with OPC (As per approved Design mix) , Inhibitor Coated Reinforcement Bar Fe 500 are material used for construction of Pier.



Fig. Pier at Nagpur Metro Construction Site

5.2 Girders and Types of Girder

The simplest structural forms for bridge spans supported by an abutment or pier at each end. Types of girder used are I girder, Composite girder and Box girder.



Fig. I girder platform level



Fig. Reinforcement of I girder



Fig. Composite Girder



Fig. Composite Girder section at Ramzhoola, Nagpur



Fig. Segment of Box Girder

Method of launching of Girder:

The method used for Launching of segment is by span-by-span method done by using launching gantry. This method is adopted where the long bridge deck is constructed. This method is most economical technique for erecting segmental bridge in the medium span range. This method offers a very high speed of construction. It can be used in conjunction with an erection truss under the bridge segment or an overhead

erection gantry to guide the precast element into position.

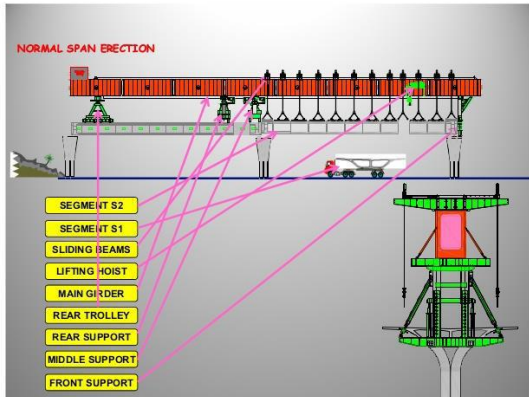


Fig. Erection by using span by span method

VI.NAGPUR GREEN METRO

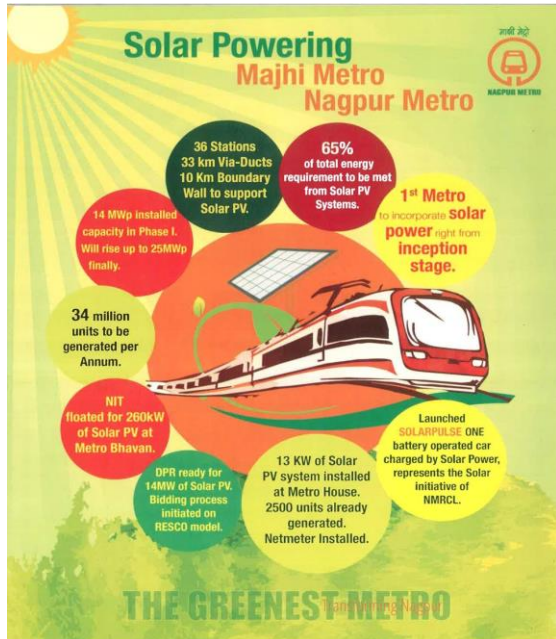


Fig. Features of Greenest Metro

Features of Green Metro

6.1. Green Initiative: -

a) Nagpur Metro will be the pioneer in adopting and integrating solar energy generation right from the project planning and design stage to meet its energy requirements to the tune of 65% which will make it the “Greenest Metro”.

b) All station roof-tops, depot boundary walls, depot shed rooftops and vacant ground spaces will be mounted with solar PV panels.

c) In Phase - I, 14MW solar power is proposed to be generated which will rise to 36 MW in future so as to met 65% of the growing energy requirements of NMRCL.



Fig. Solar Panel

6.2 Green Building: -

a) Nagpur Metro has been following the Green Building norms for environment protection in all its building design & construction to an optimum level so as to have an eco-friendly, low energy & low water consumption building and at the same time providing fresh & healthy environment to its occupants. Nagpur Metro has installed solar power panels on top of the buildings.

b) Existing Metro House is generating 13 KWp and the under-construction Metro Bhawan shall be generating power 260 KWp.



Fig. Green Building

6.3 Tree Plantation: -

On Forest Day, 5000 trees planted. Nagpur Metro is extending the programed creating “little wood” in that area. As per compensatory afforestation norms, five trees will have to planted for one felled in city and for rural areas two trees will have to planted against one. Thus takes the total to 1840 but planting 5,000trees. Transplantation of trees using scientific

methods for better survival rate was given by Maharashtra Metro Rail Corporation Limited .A demonstration of transplantation was given by MMRC at newly constructed metro station ,near Kadbi Square.



Fig: Tree Transplantation

6.4 Bio Digester Technology: -

a) An apparatus in which organic waste material is decomposed by microbial (an-aerobic bacteria) action with the production of biogas. The system is sustainable, totally eco-friendly, conserves water and produces fuel gas.



Fig. Wastewater Management



Fig .Bio Digester at Depot



Fig. Bio Digester Installation at Office Camp

b) Nagpur Metro goes a step further towards making it the greenest Metro. NMRCL and DRDO (Defence Research and Development Organization) signed a MoU for propagation and installation of “Bio Digester Technology”.

c) Nagpur Metro is the first Metro in India to adopt this technology with an objective of keeping Eco friendly clean environment and make use of organic waste and wastewater.

d) MAHA-METRO wants 100% recycling of used water so that, not a drop of water is wasted.

e) No discharge to public drain leading to elimination of ground water contamination.

6.4 Superior Project Management through 5D-BIM:

5D-Building Information Modelling (BIM) – IT based platform is proposed to be used to ensure tight control over costs, time, quality and safety of the project for the first time. NMRCL would be a pioneer in this respect also. 5D BIM is a construction project management system in which the 3D computer automated designs (CAD) are linked with schedule (time) constraints and then with cost-related information.

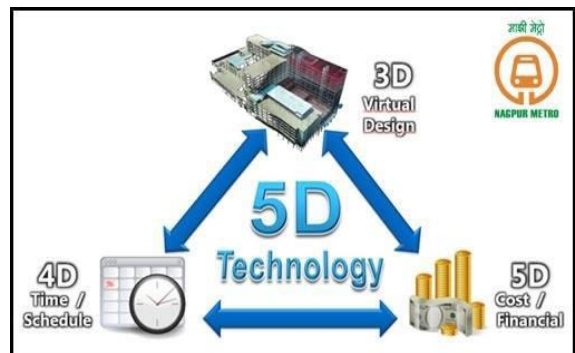


Fig.5D BIM Technology

5-D functionality can integrate design, cost, and schedule in a 3-D output.

Building information modeling (BIM) is a digital representation of the physical and functional characteristics of a project, forming a reliable basis for decisions during the project's life cycle.

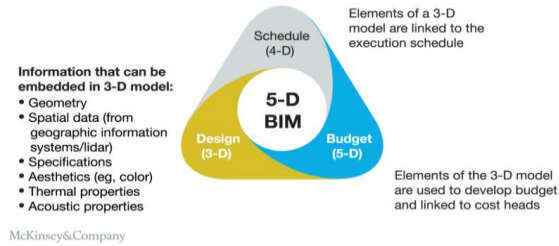


Fig. Concept of 5D BIM Technology

VII. CONCLUSION

By Studying collecting data about Nagpur Metro Rail System as Multilayered Mass Rapid Transit System, we can conclude that we can use Metro Rail system as a main mode of public transport because it facilitates quick ,safe and large number of people movement in a very economical manner .MMRTS of Nagpur City is eco-friendly as it reduces air and noise pollution .Use of advance 5D BIM Project Management technique made it more effective.

- The success of any Public Transit system mainly depends on its accessibility from various parts of the city. Wherein for MRTS the route is predefined and connectivity to all parts of the city is not possible. So a secondary system should be established which helps in augmenting the ridership of the primary system by providing proper connectivity. This supporting system is called as a Feeder System.
- Multi-modal mass rapid transit system gives combines the benefits of driving ,bicycle, walking with the benefit of rapid transit i.e metro while balancing some of the major disadvantages of each individual mode.
- Use of metro gives cost advantages to its user include lower fuel and maintenance costs of their personal automobile, and increased automobile life.
- Precast girder will provide ease in construction
- The environment will be quite protected and sustained due to MRTS Nagpur metro.
- Nagpur metro MRTS will connect the residential area with the commercial area which will be an advantage for the worker as their accommodation is very expensive at a prime location.

There is a need for providing such multi-modal mass rapid transit system (MMRTS) to make public transport system most efficient for passengers in terms of time saving, energy consumption, reductions in accidents and reduction in traffic congestion during peak hours. But limitation for application of MMRTS are

- Initial cost of construction is high.
- Road blockages during construction period.
- The area under metro line and metro station blockage the sky i.e area under shadow.
- Large number of trees need to cut down due to construction of Metro. Afforestation and Rehabilitation of trees are not enough to compensate the environment hazard.
- Electricity consumption is high as a green metro, but all electricity requirements do not fulfill by only solar system ,require using other source(Thermal Power).
- Transplantation of big trees by MMRC was failed in case of Nagpur Metro.
- There are no big industries in Nagpur. Most of the existing industries of MIHAN having their own transportation facility i.e bus for their workers and employees. Then how metro mitigate their running expenses and generate revenue to mitigate construction cost liabilities.

Future Scope

MMRTS allows larger number of people to travel from one area to the other area in the predetermined time. Nowadays, pollution has become main concern for the Government as different ways are being explored to reduce the pollution problems .The MMRTS helps in low energy consumption, is eco-friendly (runs on electricity, thus minimizing air and sound pollution), averts the number of accidents, it is efficient in terms of space occupancy and provides comfort with ultra-modern coaches and modern systems like automatic ticketing, advanced signaling systems, automatic train protection system and integrated security systems. Therefore, laying of track and track geometry, Design of Double Decker, Design and detail construction methodology of metro station etc can be further studied

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