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Hyderabad Metro System - Web Development

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Abstract

Hyderabad city is a large metropolitan city in India which has a high level of population and the traffic and transportation problems are rising over the past several years. As the existing transportation modes – buses and trains – are already saturated, there is a need for developing Mass Rapid Transit Systems (MRTS). Recognising this, the Hyderabad Metro Rail Project (HMRP) was planned to be developed as a Public-Private Partnership (PPP)model in India. The HMRL project suffered from several challenges and yet it is on the verge of completion in terms of technical execution.. This paper discusses the salient technical features of the HMRP towards addressing traffic and transportation of the Hyderabad city. The technical analysis covers the details of metro rail route alignment, horizontal, vertical and cross-sectional details of structure, design of the project structures, construction methods and processes, operational arrangements etc. These features make the HMRL as perhaps one fo the well designed and developed project that has been executed with perfection.

Key Words: *Mass Transportation, MRTS, Hyderabad Metro Rail and Technical analysis*

1. INTRODUCTION

Many modern metro rail transit lines utilize elevated structures as they represent sometimes the only possibility in built-up urban areas. Billions of man hours are lost with people 'stuck in Traffic'. The reasons are well known: exponential growth of motor vehicles with negligible increase in road space. This fact is also echoed in Govt.'s National Urban Transport Policy (NUTP). Public transport plays a major role in catering to the commuter traffic in Indian cities. The rail based mass rapid transport system which is believed to be the best solution, is already operational in Metropolitan cities like Kolkata, Delhi, Mumbai and performing well to the satisfaction of local commuters. Following the success the new metro projects are either being constructed or are in the advanced stage of implementation in a few cities: Kochi, Chennai**, Hyderabad**, Jaipur and Pune. Hyderabad is one of the largest cities of Andhra Pradesh State. Hyderabad has grown manifolds over the last two decades in terms of area, population and habitation. In order to cope with ever increasing traffic and growing travel demand a Mass Rapid Transport System (MRTS) that involves a 72 km elevated

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metro project was proposed for Hyderabad city. The metro rail project is under development stage on three high traffic density corridors, the route details are explained in the subsequent article. The metro will have 62 stations and the project apparently won several international awards for unique project development concept.

Various Formats of Metro

In fact, the underground, elevated and surface rail systems are three different mobility options, with vastly different costs and impacts. Therefore, they must be treated as three distinct options, and an objective framework must be developed to decide which of the systems would be suitable under what conditions, given the impact of such systems on urban fabric and form. **Elevated metro** systems are not viable solutions for areas that are already dense and built- up. While direct and tangible costs of an elevated option may be lower, the underground option is more cost-effective from a total cost and full life cycle perspective. It is also said that the elevated metro stations reduce the motorable width of roads to over 30%. This will deteriorate traffic and result in congestion on the roads. The massive structure of elevated metro shall change the skyline as it will be enforced over crowded arterial routes with virtually no open space. The impact will be the worst in terms of quality of life for several generations to follow. The present day costs of the elevated and underground metro system are Rs. 234 cr. per km. and Rs. 614 cr. per km. respectively. On the other hand, though it is huge, the investment in the underground metro could result in the reduction on road user cost. The citizens of the city will gain substantially with the introduction of the underground metro service as it saves travel time due to reduction of congestion on the roads and lower travel time of the Metro. There will be health and other environmental benefits to the public due to reduced pollution from the transport sector of any Metro system. However, when there is no land available (as in case of surface metro) and/or there are too many unknown underground utility lines criss-crossing, the elevated metro is considered to be a good choice of metro systems in the cities. This is the situation of Hyderabad city, which has huge shortage of land and large unknown underground utility systems.

2. METRO RAIL ALIGNMENT AND PROJECT PHASES

The following figure shows the route alignment map of Hyderabad Metro.

Source: http://hyderabadmetrorail.com/routemap.html

The Phase I of the project includes 3 lines covering a distance of around 71 km. The metro rail stretches between Nagole and Secuderabad 11 km is targeted to be operational by December 2015. The entire 72 km 66-station first phase is due to be completed by December 2017.

- Miyapur – L B Nagar - 29.87 km
- Nagole - Shilparamam - 26.51 km
- JBS – Falaknuma - 14.78 km

The Government sanctioned second phase of metro rail extending further 85 km. The proposed routes are as following:

- Miyapur - BHEL - Patanchervuu 15 km.
- Faluknama - Shamshabad Airport 12 km.

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- LB Nagar - Vanasthalipuram 4 km.
- ECIL - Tarnaka 7 km.
- Nagole - LB Nagar - Faluknama 15 km.
- JNTU - Shilparamam - Gacchibowli 14 km.
- JBS - Alwal 8 km.
- Gachibowli - ToliChowk - Lakdikapul 17 km

3. COMPONENTS ELEVATED METRO LINE

I. Elevated Metro/Viaduct :

The proposed viaduct structure for the Hyderabad Metro is a 'U' shape deck carrying two tracks on single pier located on the median of the road. The width of the deck is 9.1 m and the pier will be 1.45 m to 1.6 m diameter. A road clearance of 5.5 m is ensured below the viaduct structure. The foundation shall be open foundation at most of the locations though pile foundation socketed in rock may be necessary at certain isolated locations. The superstructure shall be pre-cast segmental construction which will cause minimal inconvenience to the road users. The other **key aspects are it a*ccommodates two directional tracks, built on single pier, made up of single box girders.***

II. Construction Process:

a) **The construction equipments** are selected based on the size of the project, the environment of site (built-up area), safety and quality and minimum inconvenience to the general public and existing traffic flow. The major equipments used in this project are gantry cranes, piling rigs, power generators, transit mixers, batching plants, RMs units wheel loaders, stone crushers, launching girders, etc.

b) **Building super structure:** It is made up of pre-cast segmental technology. The pre-cast segments are prepared at designated yards set up in the land provided by the Government on temporary basis under strict supervision. Usually the the yards are considerably away from the city, in this case they are located in Uppal and Qutubullapur. The pre – cat and pre-stressed segments thus cast in these yards are transported to the project site and to the place of viaduct alignment by launching girders deployed at the site for this purpose.

c) Grade of concrete and steel: For construction of various structures the following grades ofconcrete and steel is used:

M-30 : Pile cap and open foundation

M-40 : Piers

M-45 : All pre-cast elements for Viaduct and stations

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M-30 : Other Miscellaneous structures

HYSD 415 or TMT steel RECC Works

High tensile steel strands with configuration 12 T 13 or 19 K 15 for pre-stressing members(Confirming IS: 14268)

Design stipulations

Characteristic compressive strength of concrete = 45 N / mm2

Maximum size of aggregates = 20 mm

Degree of workability = Very Good

Compaction factor = 0.75

Degree of quality control = Very goodPile integrity test is conducted to assess the condi

d) Pile Construction Procedure in Brief:

Utility checking is conducted in order to finalise the exact location of the digging building the pile and installation of the pile is done as per the drawing approved by the consultant. The key operations involved in the pile construction are pre tube driving, boring pile hole, Reinforcement cage fabrication, lowering of cage in to the bore, concreting, etc.

III. Operational features: Features and Descriptions

i. Average Train speed : 90 kmph

ii Gauge : 1435 mm (standard0

iii. Curve length : 25 m

iv. Cant : 125 mm

v. Grades (station) (max.) : 0.1%

vi. Grade (mid section) (normal) : 2% 4% (exceptional)

vii. Track structure : Ballast less track conform to the UIC 717-2R (international union of Railways)

viii. Rolling stock : Shall fulfil the condition of UIC 512

ix. Width of coach m : 3.2

x. Height of the coach m : 4.0

xi. Length of coach : 21.34- 21.64m

xii. Capacity : 45 seated 250 standin

xiii. Power / Traction : 25 KV AC 50 Hz.

xiv. Continuous automatic Train control (CATC) system

xv. Automatic fare Collection (AFC) system

xvi. Automatic train supervision system (ATSS)

xvii. Optical fibre cables telecommunications for system efficiency

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xviii. CCTV

xix. Computerized accounting system.

4. SALIENT FEATURES OF METRO STATIONS

The Delhi metro station plan has been considered as a basic model for the station development scheme. However the size of the stations for Hyderabad metro is comparatively small as it is designed to fit in the existing road alignment. The other salient features are as follows:

- Length of the station – 138m
- Width of the station – 20.25m
- Height of the station – 24.21m
- Typical span of the station – 13.4m/17m
- Station consists of 2 level slabs (Concourse level & Platform level)
- Concourse level structural system is of Spine beam and wings. Spine beam rests on Pier cap and Cantilever wingsare fixed to spine beams on either side
- Platform level structural system of Diaphragm beam on top of pier cap with Precast longitudinal girders spanning between them. Decking system is of cast in-situ slab.
- Roofing system – Structural steel supported with sheet.

Fig. 1 : Station Elevation Stage

- Natural ventilation for public areas
- Façade and Roof designed to maximize weather protection
- Roof designed to cater for solar panel provisions
- Rainwater harvesting
- Appearance to reflect the contemporary high speed rail
- Form dictated by the functional requirement and tailored to fit in with the site constraints of the urban scenario ofHyderabad
- Station entry/ exits modified as per site conditions

☐ 5.5m minimum ensured above all street levels

5. PROJECT EXECUTION STAGES

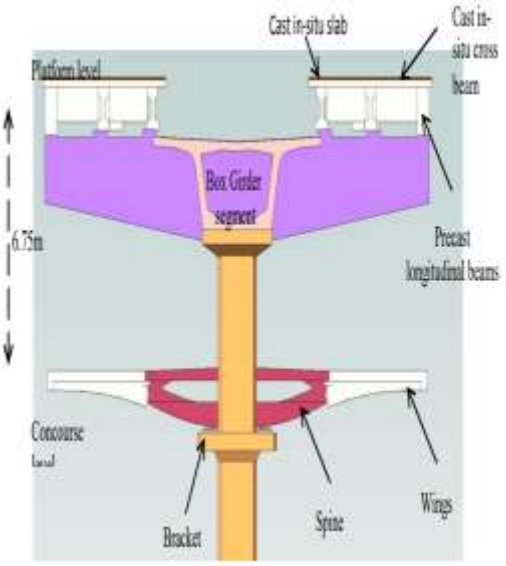

Fig. 2 : Station Super Structure

Construction Sequence

Stage 1

➢ Provision of brackets in pier for placing of spine beam

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Stage 2

- Construction of Cast in situ cross girder at Platform level with cantilever support from pier

Stage 3

- Completed view of Cast in situ cross girder at Platform level

Stage 4

- Lifting of Spine beam S1 at concourse level using launching girder

Stage 5

- Erection of Spine beam S2 using launching girder
- Segments are positioned and locked with Macalloy bar to main beam of Launching girder

Stage 6

- Segment S3 is held little away from the actual position to create extra space for fixing of other segments
- Lifting of Segment S4 using Launching girder

Stage 7

- Completed view of Spine erection using launching girderPre-stressing is done

Stage 8

- Releasing the spine segments from Macalloy bars only after pre-stressing is done.

Stage 9

- Positioning of Spine Segment from Temporary stool to bearing using Flat jacks

Stage 10

- Deactivate the main jacks

Stage 11

- Side shifts the main girders by Hydraulic cylinder to right side. Then, Activate the Gantry crane Anchorage.

Stage 12

- Lifting of Platform level longitudinal girder on left side at platform level using launching girder

Stage 13

- Lifting of Platform level longitudinal girder on left side at platform level using launching girder

Stage 14

- Side shift the main girders by Hydraulic cylinder to left side. Then, Activate the Gantry crane Anchorage.
- Lifting of Platform level longitudinal girder at platform level on right side.

Stage 15

- Lifting of Platform level longitudinal girder on left side at platform level using launching girder

Stage 16

- Side shift the main girders by Hydraulic cylinder . Then, Activate the Gantry crane Anchorage.
- Erection of wings segment and locking it with beams in Platform level girders using Macalloy bars

Stage 17

- Lifting of wings segment and locking it with beams in Platform level girders using Mac alloy bars

Stage 18

- After completion of lifting of wings segments, launching girder is moved to

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next bay

Stage 19

- Pre-stressing of Wing segments/Stitch Slab is casted in between the wings
- Erection of Spine segments in next bay

Stage 20

- Wings segments are released from macalloy bars after stressing is done.

Stage 21

- Completed view

Stage 22

- Completed view of cross beams at platform level

Stage 23

- Casting of slab at platform level

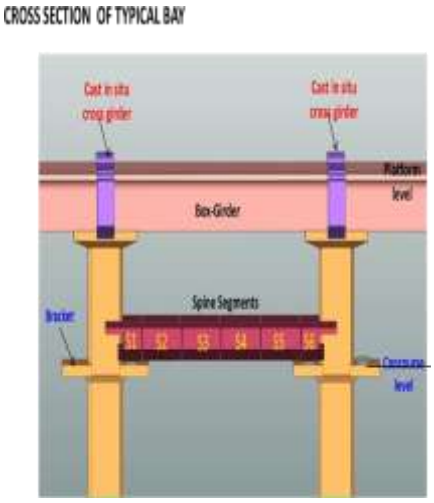

Fig. 3 : Elevation of the Metro line

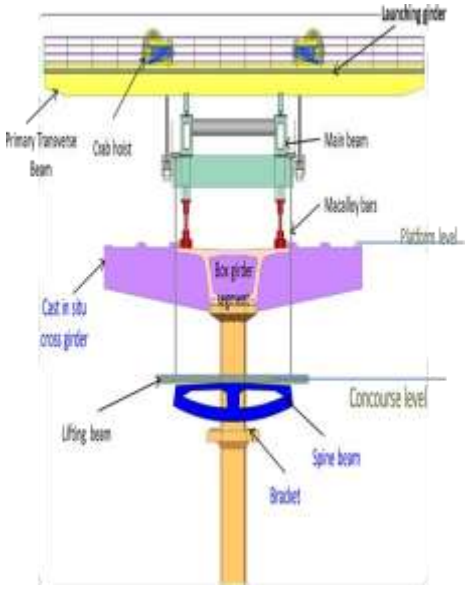

Fig. 4: Launching Process of the Girder

6. Rolling Stock

Rolling stock for Hyderabad Metro has been selected based on the following criteria:

- Proven equipment with high reliability;
- Passenger safety features, including fire resistance;
- Energy efficiency;
- Light weight equipment and coach body;
- Optimised scheduled speed;
- Aesthetically pleasing Interior and Exterior;
- Low life cycle cost; and
- Flexibility to meet increase in traffic demand.

The controlling criteria are reliability, low energy consumption, light weight and high efficiency leading to lower annualized cost of service. The coach should have high rate of

acceleration and deceleration. Keeping the above features in mid, 2.88 m wide stainless steel light weight coaches are proposed for the Hyderabad Metro, with length of 20.8 m for trailer coach and 21.05 m for motor coach. Height of coach is 3.8 m. Train length for 3 coach train in 64.1 m while that of 6 – coach train is 128 m. The Axle load is about 15 t for which the structures are to be designed. Traction motors are 180 KW and propulsion system is 3-phase drive with variable voltage and variable frequency (VVVF) control. Trains will have regenerative braking system to save energy cost. Current collection is through bottom collection from third rail at 750 Volt dc. Trains will be air-conditioned and provided with automatic door closing and opening system. The trains will have state of the art cab signalling with continuous automatic train control and automatic train protection system. The trains will have passenger information and announcement system. Coaches have longitudinal seats with a seating capacity of 50 per coach and total dense crush capacity of 322 (MC) to 356 (TC), at 8 persons/sq m.

7. CONCLUSIONS

Urbanisation is a reality and India is in the throes of it. With Hyderabad being the capital of a newly formed state in the country, there has been a constant push by the government and its administration to make it a world class city by developing infrastructure ("Hyderabad to host 5th Smart City Summit", 2018). As seen in the report, the Hyderabad Metro Rail is a step towards urban transformation. Created mainly for the growing city population, the introduction of the metro has broader implications beyond its immediate purpose.

One of the fastest growing metros in India, Hyderabad has created an image of being a geographically strategic, multilingual cosmopolitan city to attract investment in different sectors such as IT and commerce ("Why Metro", n.d.). In this regard, the Hyderabad Metro Rail can be seen as part of the city's tremendous Public Relations (PR) exercise. As can be extracted from the study, the metro is aimed at reducing traffic congestion, pollution and providing comfort in travel for all people, thus making it a new alternative. This can be seen in conformity with the SMART city model that emphasizes on liveability, workability and sustainability. However, it is important to note whether the establishment of the metro has been successful in catering to all its users.

Contributing to urban and social transformation, the metro is seen as a gender-neutral space. While there have been suggestions of reserving seats/coach for women, it was also noted that the presence of security personnel and metro staff itself makes the space accessible for everyone to a large extent. Apart from this, the metro is also an inclusive space in terms of disability access. With features such as tactile paving and lift services, the metro attempts to become an urban space for all. Nevertheless, there are areas of concern which may hinder the metro's and even the city's goal to become a world class city with quality and inclusive urban spaces.

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