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MAY 2019

MMRC
ADDING NEW DIMENSIONS

METRO CUBE

A MUMBAI METRO RAIL CORPORATION NEWSLETTER

Content

MD Speaks

Ms. Ashwini Bhide, IAS

Preparation of Monsoon is a critical activity in Mumbai for all infrastructure agencies in the month of May every year. MMRC Engineers, Consultants and Contractors were fully devoted to make sure all Metro-3 construction sites are monsoon ready by attaining safe working stage, ensure proper flow of storm water drain (SWD) located in the vicinity and be prepared to avoiding flooding of any of the public roads and thoroughfares. The preparedness also includes to be ready to handle any eventuality that may occur due to heavy rains. Various works of cleaning SWD delisting and maintenance were carried out along with deployment of heavy duty pumps at flood prone areas, illuminating roads, barricades etc. All these activities were taken up in complete coordination with MCGM officers. Our emergency helpline numbers will be activated from 1st June for an assured support to the citizen in case of emergencies.

Continued on Page 3

Interlocking in CBTC Systems

CBTC (Communications Based Train Control) is an automatic train signalling system which is operated by telecommunication between the train and track equipment for the traffic management and infrastructure control. Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time, heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting radio based CBTC system.

Primary characteristics of a CBTC

- High-resolution train location determination, independent of track circuits
- Fixed beacons for refining train location information
- Secondary detection system for safety during degraded mode of operation
- Continuous, high capacity, bidirectional train-to-wayside data communications
- Train-borne and wayside processors performing vital functions
- Conforming to International IEEE (Institute of Electrical & Electronics), EN standards (European Standards) for (Radio Frequency) RF-CBTC and safety operation

Evolution of Signalling System

1. Space Interval System

a) Absolute Block Signalling: 1 train at a time between stations (non-suburban sections)

b) Automatic Block Signalling (physical signals between stations)

i. Conventional: Manual Operation with Automatic Train Protection (ATP) and Train Management System (TMS), e.g., Mumbai Suburban Section.

ii. Distance-to-Go (DTG): Automatic operation with Automatic Train Protection (ATP), Automatic Train Operation (ATO) and Automatic Train Supervision (ATS). Physical/virtual signals between stations to separate trains, e.g., Mumbai Metro Line-1.

2. Time Interval System (Moving Block System): No physical or virtual signal between stations due to time intervals maintained between trains through moving block system, e.g., CBTC (Grade of Automation-2/3/4)

a) Semi-Automatic Train Operation - GoA 2

b) Driverless Train Operation -GoA 3

c) Unattended Train Operation -GoA 4

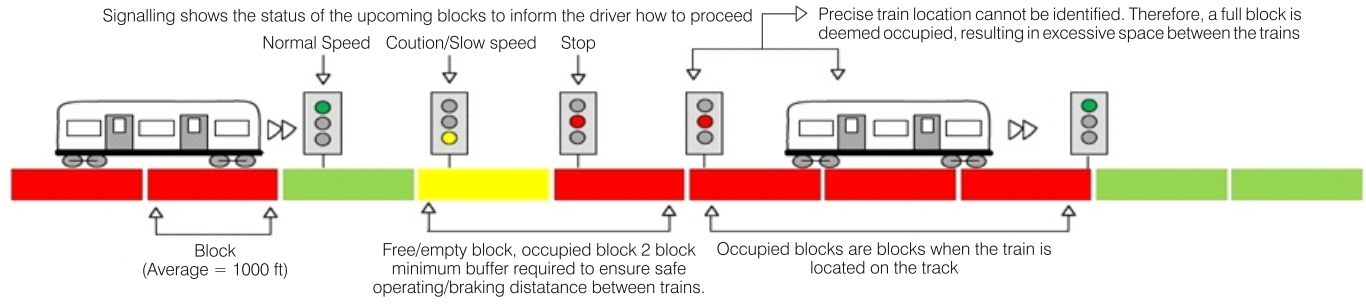
Zone Controller

In conventional CBTC systems, trains regularly send their location report to a zone controller. After processing the reports, the zone controller sends back an "end of authority" for each train which enables the train to define its speed control curve. This enables trains to operate at lesser time intervals, thereby enabling reduced headway when additional train sets are introduced.

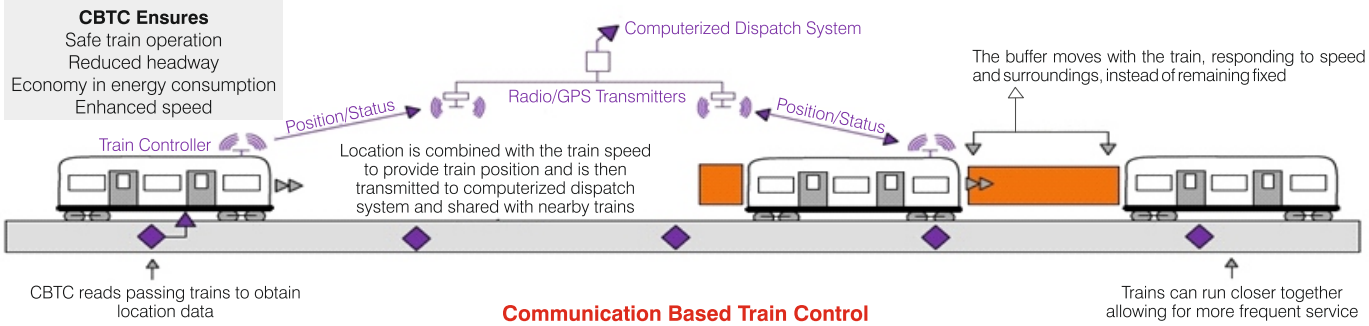
Interlocking

An arrangement of switch, lock, and signal devices that are located where rail tracks cross or join for controlling train movements or their diversions on other tracks. The devices are interconnected in such a way that their movements must succeed each other in a predefined order, thereby ensuring safe train movements.

Continued on Page 7



Fixed Block Signal System



Communication Based Train Control

Types of TBM

This is the last article in continuation with the series on 'Types of TBM', in April 2019, Volume 31 issue.

Earth Pressure Balance TBM

EPB machines will excavate approximately 14.8 km of the twin bore running tunnels through seven EPB TBMs. Three TBMs are being supplied by Herrenknecht, two by Terratec and two by Shanghai Tunnelling Engineering company.

EPB machines were chosen along these sections of the alignment primarily because of largely varying geological conditions and surface features, such as rivers, railway tracks and the reduced cover to sensitive structures.

The contractors and TBM manufacturer concluded that the following geological risk existed at various sections along the alignment:

- Unstable face - weak rock mass (soil-like) and water
- Material erosion at the face - weak material which can be washed out by water flow or disintegrates in contact with water
- Weak joint fillings which can be washed out by water flow leading to blocky failure
- Localized / concentrated water inflow which may erode material in the weak layers above resulting in sinkholes and volume loss
- Small block fall at the face resulting in local instability

Design features of the EPB TBM

Based on the geological data provided by the contractors, additional geotechnical investigations and the following special features were considered appropriate.

- Large opening ratio of between 28 and 35%
- Additional injection ports in the cutter head to enhance soil conditioning
- Closer spacing than normal for forward probing and ground enhancements
- Bespoke cutter head design with closer spaced disk cutters, scrapers and peripheral cutters to accommodate the large opening ratio.

Conclusion

Due to the fast track approach in construction of Metro-3 project, a clearly defined and systematic approach was taken in the design development and choice of the TBM to be used during tunnel excavation. Outline design of the TBM were developed in parallel with other designs, such as segmental lining, appropriation of additional geotechnical information, construction methodology and building condition surveys. Additionally, close collaboration between client, contractor, TBM manufacturer and General Consultant combined with the iterative design process contributed immensely to the successful delivery and launch of the TBMs, a unique approach, one which has proved to be successful. Other factors, such as development of detailed Factory and Site Acceptance Test methodology ensured that all TBMs were tested before delivery and launch respectively. Tunnelling operation has commenced and all initial indications seem to suggest that they are performing satisfactorily with average excavation rates predicted to be in the order of 20 to 25 m per day for each TBM in varied and difficult ground and operational conditions.

MD Speaks

Continued from Page 1

This month, the Metro leadership had opportunity to represent the project at a global level at World Tunnel Congress; prestigious platforms for global tunneling professionals held this year at Naples, Italy. The Congress is attended by 2000 delegates; experts, professionals and entities working in tunneling from over 60 countries. MMRC team contributed a few papers in the congress, along with discussions on key areas of tunneling apart from showcasing the project. The take-aways and learnings from this conference will help in further improvement of Metro-3 works and project delivery.

Station construction at different locations is in full swing at almost all stations. Note worthy among them is Marol Naka Station of Pkg 7 that achieved completion of 100% base slab this month. Construction of 158 m long NATM tunnel under Mithi river started taking shape with lining works for first section started. This month witnessed 13th tunnel breakthrough at Vidhan Bhavan Metro Station after 1240 m tunneling from Cuffe Parade that had 838 rings. The average production achieved was 07 rings/day. The completed tunnel length now stands at 27.05 km out of total 55.18 km and 50% Tunneling is expected early next month.

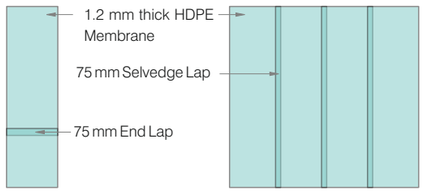
On system front, technical bids for Pkg 9 - Subpkg 01 were opened for two lots; Lot 1- CNC under floor wheel lathe and Lot 2 - Battery operated shunter. Now technical bid evaluation is in progress.

Team MMRC wishes Mumbaikars a safe and pleasant monsoon. We encourage the citizens to be informed of the heavy rainfall days coinciding with high tides and plan their routines. Also keep MMRC informed of any incidents around our project site through the emergency help line for a timely response.

Waterproof Metro-3

In last two issues, we have covered the adopted waterproofing technologies for tunnels, constructed by TBM and NATM. Now we will see the waterproofing in station box. In the underground stations of Metro-3, waterproofing is being done using fully bonded membrane 1.2 mm thick HDPE (High Density Polyethylene) membrane for base slab and walls with confined space (clear working space less than 0.7 m is available) on outer side. Whereas, for upper portion of unconfined areas of walls and for roof slab area, 1.5 mm thick liquid, polymer cold applied polyurethane membrane or preformed post applied self-adhesive membrane of total thickness of 3 mm applied in two layers of 1.5 mm thick.

Waterproofing treatment for base slab: Using fully bonded Membrane 1.2 mm thick, HDPE membrane



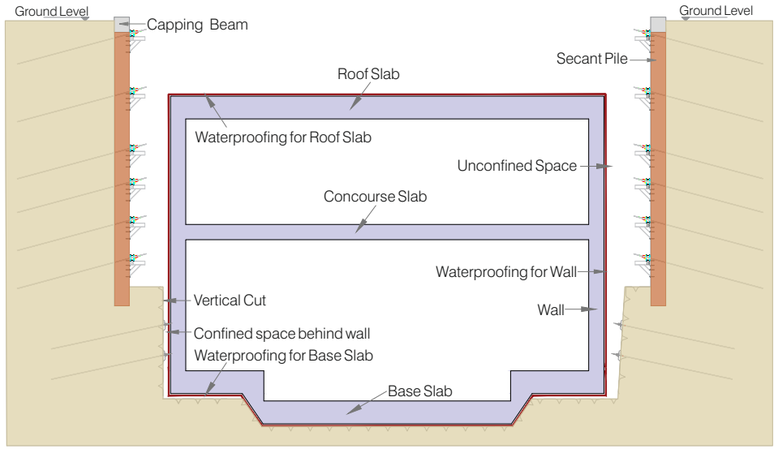
The 1.2 mm thick HDPE membrane is laid over the PCC before casting the RCC base slab, on horizontal surface area with standard 75 mm selvedge laps and 75 mm end laps. The prebond membrane is turned up on to the prepared smooth shotcrete for minimum 300 mm and thereafter continued as part of the retaining wall treatment. Adequate care is taken while tying rebar to avoid unnecessary damages to the membrane.

Waterproofing treatment for retaining wall / RCC wall for confined area (working space less than 0.7m)- Using HDPE fully bonded membrane

Selvedge Lap

It is ensured that the shotcrete on excavated surface is done in a way that all bolts and anchors are fully covered and shall be free from any protrusions, like fibers, etc. The Membrane is installed 300mm above the 1st Lap location for Vertical Reinforcement (Dowels) of the Retaining Wall / RCC Wall. Nails are provided along the 75mm selvedge joint at every 1m C/C interval, or as deemed necessary to hold the membrane in position and to be subsequently covered by the overlapping membrane. Nails are provided at 500mm c/c at the 75mm end lap of the membrane and which are covered by the overlapping membrane, are lapped by using double sided tape.

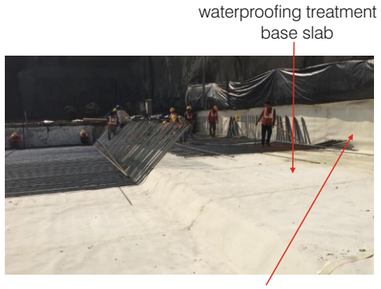
Thus in both cases it is ensured that the nails are not directly come in contact with Concrete. During concrete pouring, care is taken the Prebond membrane gets bonded to the poured concrete of the Retaining Wall / RCC Wall to provide a positive side waterproofing protection.



Typical section for waterproofing treatment at Station Box

Installation of Re-Injectable Hose System:

Re-injectable hose system is installed at the construction joints in the Retaining Wall / RCC Wall / diaphragm wall including injection ports / boxes for carrying out post construction injection grouting wherever required. Polyurethane / Polyacrylate Resin based grouting / Low viscosity resin base grouting is to be carried out through the Re-injectable Hose or at any other leaking spots in the Retaining Wall / Raft Slab, as per site requirement, using special injection grouting pump to full saturation wherever required. Non bentonite based Hydrophilic Swelling bar is also installed along with re-injectable hose system.



the membrane is turned up from base slab to wall for water proofing of confined wall

waterproofing treatment at base slab and confined wall

Waterproofing treatment for upper portion of un-confined areas of retaining wall (clear working space of minimum 0.7 m available) and underground station roof slab area:

Waterproofing treatment on upper portion of wall and roof slab can be done by following two methods.

Method-1: 1.5mm thick liquid, polymer cold applied polyurethane membrane

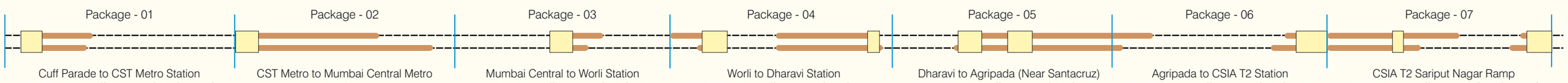
After the concreting of Walls and roof slab, "V/U" shaped groove of approx. 25 mm x 25 mm size are formed in the construction joints. Injection grouting is carried out at the construction joints, in the concrete wherever required by injecting cement slurry grout admixed with integral crystalline waterproofing admixture @ 400 gm. Elastomeric hydrophobic polyurethane resins, polyurethane membrane used for long-lasting waterproofing which result in excellent mechanical, chemical, thermal and natural element resistance properties. Cures by reaction with ground and air moisture. This system has inbuilt anti root properties.

One coat of water based epoxy primer or solvent based PU primer is applied on the external surface of the retaining wall then the polyurethane membrane is applied on the external surface of the unconfined retaining wall / top surface of roof slab by using spray/ brush/roller application in two coats so as to form a DFT of 1.5 mm thick average minimum. First coat is applied at the consumption rate of 0.9 to 1.0 kg per sqm to form the avg. DFT of 0.75mm. A 75 mm overlap at joint of previous applied membrane shall be maintained wherever work stops / next day work commencement. The coated surface is allowed it to self-cure for 7 days.

Method-2: Preformed Post Applied Self-Adhesive Membrane of 1.5mm thick each applied on each other leading to total thickness of 3mm

Surface is to be cleaned before the application of Primer. The applied primer must become tack-free before starting application of membrane. In case of any water splashes on the primed surface is wiped out with damp cloth. The protective release paper shall be peeled back and the adhesive surface of the membrane unrolled onto the prepared surface. The membrane should be brushed onto the surface to ensure that air is excluded from under the membrane. Adjacent rolls of membrane should be provided with 50mm overlap at the edges and 50mm at ends to ensure complete continuity. Then second layer of membrane to be laid with staggered joints over the base layer of membrane. Pressure should be applied at the laps with a roller to ensure complete adhesion between both layers. While laying second / top coat layer of the membrane, care shall be taken to ensure that there is a minimum staggering of 100 mm in the alignment of overlaps / joints with the underlying layer of the membrane.

Tunnel Progress Update - As on 31st May 2019



Cuff Parade to CST Metro Station
2,559 m tunneling completed out of 5,894 m

CST Metro to Mumbai Central Metro station
5,051 m tunneling completed out of 7,640 m

Mumbai Central to Worli Station
1,234 m tunneling completed out of 7,290 m

Worli to Dharavi Station
6,278 m tunneling completed out of 10,960 m

Dharavi to Agripada (Near Santacruz)
4,976 m tunneling completed out of 7,992 m

Agripada to CSIA T2 Station
2,455 m tunneling completed out of 6,937 m

CSIA T2 Sariput Nagar Ramp
4,095 m tunneling completed out of 7,079 m

Bored Tunnel Launching Shaft

Monsoon Preparedness

MMRC's precautionary measures for Monsoon

MMRC is fully geared up to face ensuing Monsoon. Detailed directives for monsoon 2019 have been issued to engineers as well as contractors for pre-monsoon measures and readiness during the monsoon.

Joint site inspections along with MCGM's engineers have already been taken place at the Metro-3 construction sites and action plan regarding monsoon preparedness has been prepared as per MCGM team's suggestions. Accordingly MMRC engineers and contractors have started pre-monsoon works at all sites which are scheduled to be completed much before the onset of monsoon. Activities, such as cleaning of Storm Water Drains (SWD) and construction of catch pits at Metro-3 construction sites influence areas are in progress and will be completed to ensure smooth flow of water.

At the same time activities for smooth movement of traffic, such as repainting of diversion signage to enhance visibility of barricades are also being taken up in the influence area of construction sites. Sufficient number of pumps of adequate capacity (Medium to large capacity pump 3hp –35hp) are kept ready at various station and tunnel shaft sites for de-watering during water stagnation.

MMRC will also coordinate with other utility agencies to maintain electrical and communication system intact during monsoon.

Muck generated from the site will be transported in watertight dumpers with tarpaulin to avoid slippage on road.

All precautionary measures have been taken to avoid mosquito breeding at sites. An emergency response team comprising of two engineers and one supervisor will be deployed 24x7 at each site under the supervision of senior engineer to monitor day to day monsoon related issues. Coordination with local ward office and disaster management team of MCGM will be maintain on daily basis. To redress monsoon related grievances, a control room will be established with 24x7 contact number which will be available on MMRC website and also on last page of Metro Cube.

Barricade Cleaning

Cleaning of Storm Water Drains

Drain Chamber Cleaning

Site Visit with MCGM officials

Cleaning of Drain Chamber

"MMRC is working to deliver an important transport system for the city. We are working in close coordination with MCGM officials to ensure that no inconvenience is caused to Mumbaikars due to Metro-3 construction works. All emergency equipment and vehicles will be deployed at flood prone areas and there will no issues related to traffic or water logging. MMRC had ensured no water logging at their construction sites during last monsoon and the same would be ensured during the ensuing monsoon as well".

Ms. Ashwini Bhide, Managing Director, MMRC

Chamber Connection work at Grant Road Station

Expert Speaks

Station name branding in Tokyo and TOD

This article is in continuation with the previous 'Expert Speaks', in April 2019, Volume 31.

Here is an intresting story related to the name of Metro Station in Tokyo. It is Toritsu Daigaku Station, a station of the Tokyu Toyoko Line, connecting Shibuya, Tokyo and Yokohama since 1926. "Toritsu" means "founded by the metropolitan government" and "Daigaku" is University. The Tokyo Metropolitan University was in front of the station during 1931 and 1991, and the station was re-named after the university in 1952.

The university moved to the suburb in 1991 and the station continued to be known in reference to the University. The name of the station had no relation with the local industry and cultural characteristics. The railway line owner, the Tokyu Railway Company, conducted a local voting among the residents to change the name of the station, however, the Tokyu company decided to retain the name as it was in the end because the votes rejecting the station name had not reached majority.

This analysis could be further interesting. During 1960s and 1970s, it was the economic growth period of Tokyo, and surroundings of the station were developed by private housing developers as residential sites having a close railway access to Tokyo and Yokohama. The developers named their condominiums as like "Toritsu Daigaku Residents", "Toritsu Daigaku City" and so on, and new middle class in the growing society admired this new housing as a symbol of cultural richness of the premises.

Toritsu Daigaku Station Main Gate

Through this kind of momentum, it seems the railway station, property and residential society were integrated, and the area was recognized "Toritsu Daigaku" without the university itself. Consequently, the local survey collected votes for no change of the station name.

This is nothing but Station Branding, one of the important aspects of TOD. In general, TOD pursues physical integration of property development and station premises; however, the society must be integrated through the branding process. This could be achieved in two ways - The pre-branding which be applied to green-field TODs. The station could be named with a posh image to attract target society. A core premises with good image can be invited to create a good image, like the "Toritsu Daigaku" station. This approach can be applied to suburban stations of the Line 3. The post-branding used to capture the present local name to the station, but the surrounding development should be controlled with a standardized branding image. This would be considered for stations in the Island of the Metro- 3.

Interlocking in CBTC Systems

Continued from Page 2

Movement authority to a train is given by the Zone Controller of CBTC System. Zone Controller is helped by the Interlocking System that decides "End of Movement Authority" for a train after duly ensuring that route is correctly set and locked for its safe movement.

Evolution of interlocking of Signalling Systems

a) Mechanical Interlocking

b) Electro-Mechanical Interlocking

c) Relay Interlocking

d)Electronic Interlocking/Computer Based Interlocking (CBI): used in Metros

The CBI system provides a very high level of availability and safety for route interlocking, controlling and monitoring the inputs/outputs of all equipment installed along the wayside in fail-safe manner. The CBI is based on entry-exit system and provides bi-directional train working.

The system interfaces with Zone Controller and Automatic Train Supervision (ATS) system. The CBI system is designed to guarantee a highest level of safety [safety integrity level (SIL 4) as defined in CENELEC EN-50126, EN-50128, EN-50129].

For Metro-3 project, distributed Computer Based Interlocking has been planned with Smart I/Os deployed at stations to carry out safety critical functions for track-side signalling equipments.

News @ MMRC

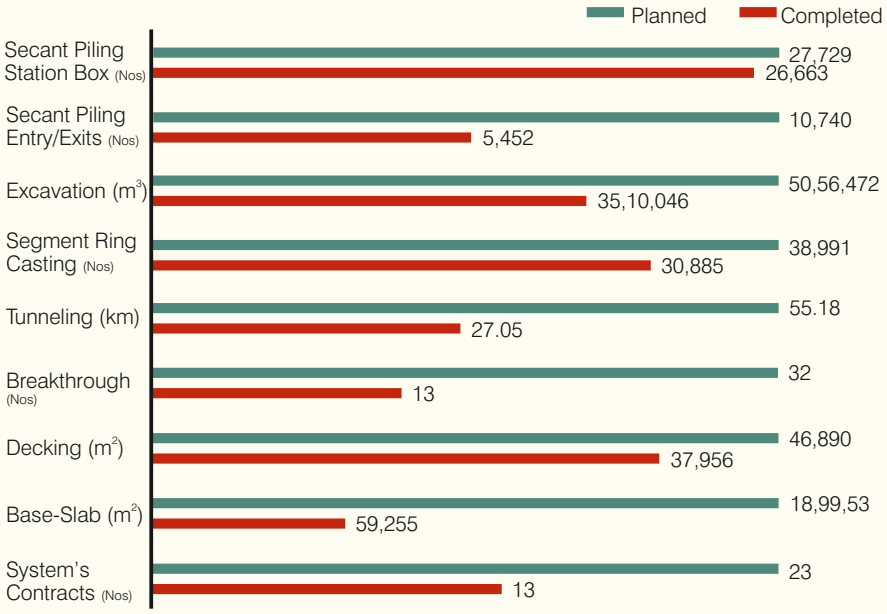
13th TBM Breakthrough at Vidhan Bhavan metro station. A 95 m long ROBBINS manufactured TBM Surya 2 weighing 600 MT tunneled across 1.24 km installing 838 rings at an average of 7 rings/day to achieve this feat.

MMRC observed international fire fighters day. A special fire fighter training was organized for workers on site at pali ground to mark the occasion.

MMRC presented paper on "Geotechnical Challenges in Design and Construction of Tunnels for Mumbai Metro line 3" at the World Tunnel Congress, which was held in Naples from 3rd to 9th May 2019. Over 2000 delegates from 60 countries participated in the Congress discussing key factors of tunneling, like long & deep tunnels, innovations, materials & equipments, geological geotechnical knowledge and also aspects of archeology, architecture & art in underground construction.

Project Progress Update

As on 1st June, 2019



Contract signing of package 16B: Heavy Duty Elevators (Lot L1), Aarey to Dadar and OCC Building (13 Stations, 76 Nos.) on 10th May 2019

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