MMRC
ADDING NEW DIMENSIONS

VOLUME 31
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METRO CUBE

A MUMBAI METRO RAIL CORPORATION NEWSLETTER

Content

MD Speaks

Ms. Ashwini Bhide, IAS

Keeping in line with consistent progress on civil works front; Marol Naka station has achieved 100% excavation of station box this month. This is the second station after MIDC completing 100% excavation on station box. About 1,08,000 cu. m of excavation has been completed along with 64% base slab. First roof level slab (part) casting in the project has been achieved at Siddhivinayak station. On similar lines, base slab and concourse slab works are also progressing at most of the stations.

New Austrian Tunneling Method (NATM) works earlier started at Cuff Parade and BKC for stabling line/crossover are progressing as planned. At Marol Naka station, NATM works to widen the TBM tunnel into station platform are showing definite progress. Cross passage works by NATM are also being taken up where TBM works are completed for up & down line tunnels.

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Tree Plantation and Transplantation

MMRC has obtained the permission for tree felling for station construction and allied activities under The Maharashtra (Urban Areas) Protection and Preservation of Trees Act, 1975 by following a due procedure laid down in the act. The permission for tree felling for depot construction activity and few other proposals are under process with Municipal Corporation of Greater Mumbai (MCGM).

Plantation

As per the permission obtained as on date, total trees required to be cut stands to 1554 trees. In response, compensatory plantation required which stands to 4662 considering 1:3 ratio. The compensatory plantation carried out at various sites, such as Aarey Colony, Mankhurd, Naval Land at Kanjurmarg, NSG land at Powai, etc. is about 2946. In addition to this, MMRC has carried out plantation of 20900 trees on degraded forest area through SGNP (Sanjay Gandhi National Park) in the month of July 2018, out of which 11,300 trees are entitled for compensatory afforestation and rest are CSR (Corporate Social Responsibilities) activity of plantation by MMRC.

Compensatory Plantation of Indigenous species; Mohagani, Arjuna, Kadmb, Karanj, Bahava, Jangali Badam, at Aarey colony, Mumbai

Transplantation

Transplantation of trees aspect carried out factors, like categorizing trees into small, medium, large size depending upon the site conditions. A different approach and preparation is required for each category of trees. Calculation of approximate root ball weight to be done in order to estimate the lifting arrangements required for each tree. Root ball preparation is very crucial aspect in this process, which is directly related to survival of tree. The site selection for receiving site is also an important factor for post transplantation activities, like post transplantation maintenance, like preparation of water basin, stalking, irrigation, application of organic fertilizer, application of pesticide and nutrient, fencing, etc. Survival of transplanted tree is depending on tree species, root ball preparation and pre & post transplantation care.

Trees Details	Permission Granted	Implementation as on 30/04/2019
Trees to be Transplanted	2042	1502
Trees to be cut	1554	1284
Trees to be retained	1401	

Pre Transplantation

Post Transplantation

Compensatory Plantation of Mahaneem and Alestonia at Naval Land, Kanjurmarg

Compensatory Plantation of Bahava, Kadamb at SRA Makhurd

Good management practices of Transplantation

- Irrigation schedule
- Periodical wedding
- Application of organic fertilizer
- Application of Pesticides
- Application of micro-nutrients
- Tree protection

Better Survival of Transplanted Trees by Good Management

Types of TBM

This article is in continuation with the series on 'Types of TBM', in March 2019, Volume 30.

Slurry TBM

Slurry machines will excavate approximately 3.6 km of the twin bore running tunnels and are being supplied by NFM/Robbins Limited. In total 2 slurry TBMs will be used to excavate the twin bore running tunnels.

Slurry TBM - Summary of Geological Conditions

Geological Description	Unconfined Compressive Strength
Fresh Basalt with infillings of Silica and Zeolites	100 Mpa
Mixed face conditions with Volcanic Breccia near the crown while greyish Basalt in invert zone	40-90 Mpa
Weathered Tuffaceous Breccia	Up to 20 Mpa
Fresh Amygdloidal Basalt with Breccia	Up to 60 Mpa
Mixed face with Basalt and Breccia	80 Mpa
Slightly weathered to Fresh Basalt	80 Mpa

Slurry machines were the machine of choice along this section of the alignment primarily because of varied geological conditions, close proximity of the tunnel alignment to heavily the congested areas and sensitive structures, condition of the buildings and the abundant availability of land for the use of desilting plant adjacent to the launching shaft.

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

- Heavy duty main bearing and mixed ground cutterhead structure to cater for soft and hard rock conditions
- Special design of the chamber allowing easy access during hyperbaric interventions for quick change over of cutting tools especially when changeovers are required beneath congested areas
- Inclusion of high capacity heavy duty 17" disc cutters and scrapers.
- Prevention of occurrence of sink holes beneath or adjacent to buildings by inclusion of full peripheral grouting
- Inclusion of a rock crusher

Design features of the slurry TBM

With poorer ground conditions along the alignment, the design of the TBM had to cater for the following geological conditions,

- Large variations in ground type over shorter distances which varied from hard rock to soft soils
- Possibility of running ground and/or face collapse under sensitive and congested areas
- Flowing and faulted ground along most of the alignment
- Possible water inflow

Some of the advantages that slurry methods include:

- Reduced wear from the abrasivity while mining in hard rock of the excavated material due to the beneficial effects of the cutters being permanently immersed in a slurry and its associated lubricating effects.
- Reduced possibility of ground settlement due to the positive face support provided by slurry pressure independent of the machine advance especially in congested areas with sensitive buildings.
- Better control of the ground and ground water pressures when excavating through soft ground/rock interface zones

MD Speaks

Continued from Page 1

Three more TBM breakthroughs have been accomplished in April with overall tunneling completed till month end being 25.40 km (46%). We are happy to note that 2 breakthroughs were achieved on same day; one at Vidhan Bhavan in the morning followed by second at Vidyanagari in the evening. Earlier in this month, Godavari-1 (Terratec make Dual Mode Hard Rock TBM) achieved the breakthrough at CSIAT1 after 2.90 km drive through Package 5&6; longest in the project as of now. These TBMs are being redeployed for next stage tunneling after necessary maintenance and refurbishment. Shifting of utilities and traffic diversion is continuous activity and an important part of the project. MMRC opened 53 m steel deck for traffic movement from Kalanagar to BKC towards Kurla that enable unhindered work at BKC Metro station. Various systems packages awarded are in the design stage and the contracts are being monitored closely.

A PAP interaction has been organized with Kalbadevi-Girgaon PAPs to discuss the final rehabilitation plans. The suggestions received are being incorporated in the final plans. MMRC has organized a Behavioral Based Safety (BBS) workshop to bring awareness on accidents, work culture, attitude, health and safety. Behavioral Based Safety Management system is a vital part of our Construction Management system to implement the project safely and within stipulated time by addressing all construction challenges.

Track Structure for Metro-3

Metro-3, 33.5 km long from Cuffe Parade to Aarey is entirely built with circular tunnels (TBM excavation). Stations are built by cut and cover technology or with NATM technology. It also includes a very short section of 0.7 km at grade at the northern tail of the line. No building is close to this at-grade section. Metro-3 has been envisioned to be the modern transport of the 21st century. State of the art technologies would be harnessed during the construction of the project to ensure protection to existing building structures. To ensure no trespassing on tracks, the station would be provided with platform screen doors.

Types of buildings above tunnels

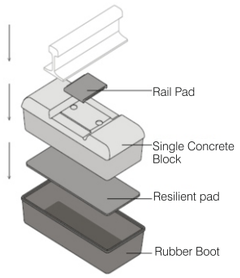
At a number of locations, the tunnel passes directly below the buildings constructed with concrete or masonry. There are old heritage buildings even above the tunnel alignment. The alignment is passing through very congested area where there are dilapidated old buildings very close to the alignment, therefore proper track structure is to be provided for safety of these structures.

Vibration Attenuation

Ground-borne vibration can be a major concern for nearby neighbours of a transit system route or maintenance facility, causing buildings to shake and rumbling sounds to be heard. In contrast to airborne noise, ground –borne vibration is not a common environmental problem. Some common sources of ground –borne vibration are trains, buses on rough roads, and construction activities such as blasting, pile-driving and operating heavy earth-moving equipment.

The effects of ground-borne vibration include perceivable movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. In extreme cases, the vibration can cause damage to buildings. Annoyance from vibration often occurs when the vibration exceeds the threshold of perception by even only a small margin. A vibration level that causes annoyance will be well below the damage threshold for normal buildings.

The vibration attenuation required for Metro-3 due to train operations has been assessed after vibration study by Central Road Research Institute. These data has been revalidated by M/s N.V. Dynamics. It is noted that the tunnel passes through hard rock form 12 m to 25 m below ground level which is good conductor of vibration and poses a challenge for designing the suitable track system to mitigate the high vibration levels.



Illustrative expanded view of booted twin blocks track

Technical Specification of booted twin blocks tracks

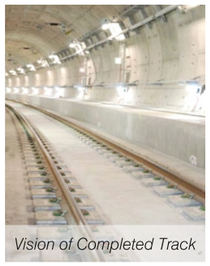
The booted twin blocks track system shall consist of reinforced concrete blocks that are separated from the concrete slab by a rubber boot especially developed for this purpose. The boot shall contain a resilient block pad below the concrete block. This elastic support of the concrete block by means of a pad, which is individually designed for each project, allows improved load distribution. An elastic rail pad shall be also used because this is decisive for one of the characteristics of this system – the dual-level elasticity.

The booted twin blocks track shall consist of single support decoupled from the embedment concrete by rubber boots. The shape of the rubber boots and structure of the rubber boot walls shall allow a free deflection of the concrete block accommodating a standard fastening system for concrete sleepers in ballastless tracks and resting on a resilient block pad.

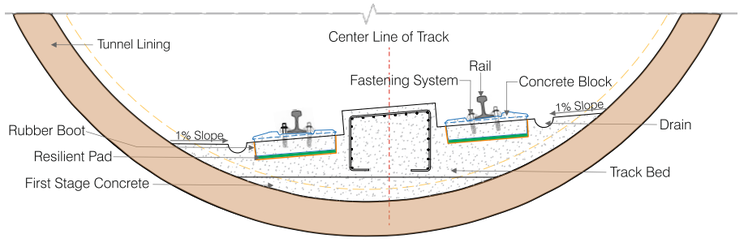
The rail support shall have a dual level elasticity, the first one directly under the base of rail and the second one under the concrete block. The static stiffness of the rail support shall be adjustable due to the selection of the block pad stiffness. The static stiffness shall range from 7 kN/mm – 35 kN/mm. The complete rail support shall be tested according to EN 13481 and EN 13146 by an independent institute. On the rail support, a standard fastening system for concrete sleepers shall be considered, meeting the criteria according to EN 13481 and EN 13230. The rail supports shall be exchangeable without demolishing the embedment concrete in short service breaks and without being influenced by the climatic conditions. The booted twin blocks track shall consists of single support to provide an unobstructed centre of track, which shall be used as passenger rescue path in emergency cases.

The following criteria adopted for selection of track structures:

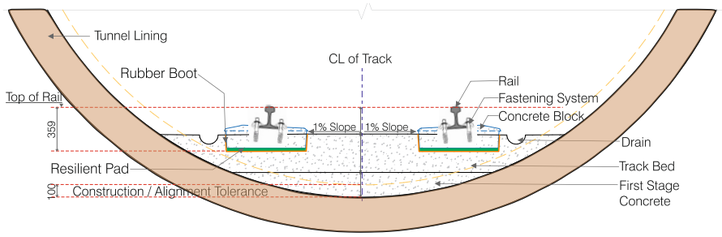
- The track structure should be able to attenuate vibration up to 22 VdB as compared with reference to conventional direct fixation track.
- The track structure should be structurally safe, easy to construct, maintain, specially to replace resilient material on periodic and need basis
- The track structure should be capable to take care of the safe evacuation of passengers during emergency.
- It should be capable of proper drainage.
- It should be economical to maintain.



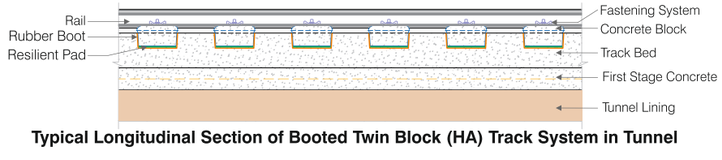
Vision of Completed Track



Typical Cross Section of Booted Twin Block (HA) Track System in Tunnel (curve R <500 m) (with derailment guard)



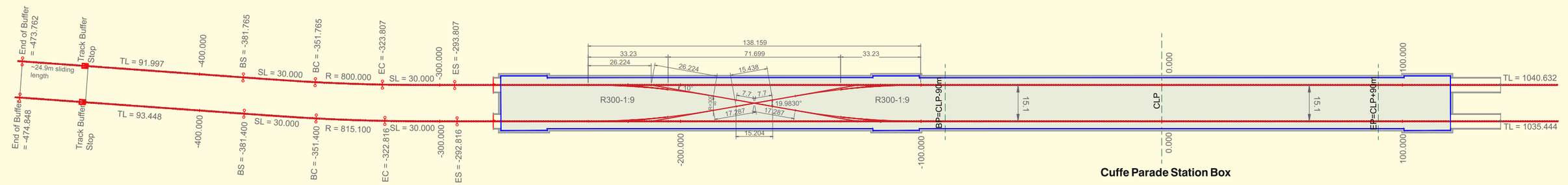
Typical Cross Section of Booted Twin Block (HA) Track System in Tunnel (Straight)



Typical Longitudinal Section of Booted Twin Block (HA) Track System in Tunnel

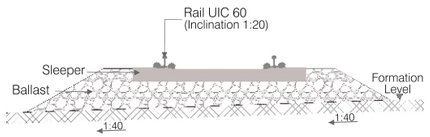
Track Design: The detailed design consultant (Track), M/s SMEC has designed Booted Twin Block Sleepers with high vibration attenuation system by following these fundamental aspects:

- Desired attenuation
- Compatibility with tunnel sections
- Easiness and rapidity of track laying
- Good maintenability: It is important to carryout repair in limited 3 hours duration of non operational period in night
- Vibro-acoustics performance
- Easy replacement
- Components reduction
- Switches and crossings installation
- Good cost performance
- Structural verification of the track

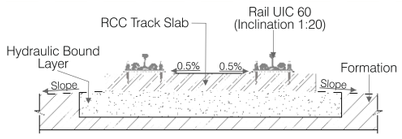


Cuffe Parade Station Box

Constructability: Booted twin block system can be constructed quite easily with a top-down approach. It has been used quite widely world over in some large installations.



Typical Cross Section of Ballasted Track



Typical Cross Section of Slab Track at Grade

Durability: Because of the absence of most steel anchoring device, which may encounter some defects of production, the system is extremely durable. The use of concrete blocks avoid any kind of corrosion problems. This twin block sleeper system is a proven technology which has been used world over such as at Dallas Tx (USA), Lantau and Airport Railway (Honkong China), Rio Metro (Brazil), East London Line (England), Copenhagan Metro (Denmark), Busan Metro Line-3 (South Korea), Incheon Airport phase I (Swedan) etc.

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Waterproof Metro-3

Last month, waterproofing technologies for TBM tunnel had been presented. This month we will cover the waterproofing technologies for NATM (New Austrian Tunnel Method)tunnel. In the NATM tunnel, waterproofing is done using PVC sheet membrane. This waterproofing shall comprise of a 500 gsm non-woven polypropylene geotextile fleece fixed to the primary lining substrate (shotcrete) in combination with a PVC sheet fastened to this and usage of drain boards with 10-20 mm dimple height in case of heavy leakages. Waterproofing shall be applied to crown and sidewalls above footing or invert ach level and below the invert slab of the tunnel portion. The PVC waterproofing membrane of 2 mm thick shall always be located between shotcrete support and final concrete lining. In case the underground structures referred to be immersed below a distinct groundwater table or in case of undrained tunnels, membrane waterproofing will be provided for tunnel inverts too.

In case the waterproofing system is to be divided into compartmentalization/sectors, the sectors should be formed of material, such as PVC water stop or as suitable, that can be hot air welded onto the 2 mm thick PVC sheet. Additional drainage capacity can be provided by studded drainage membrane made from thermoplastic material (dimpled sheet) attached prior to installation of the geotextile fleece.

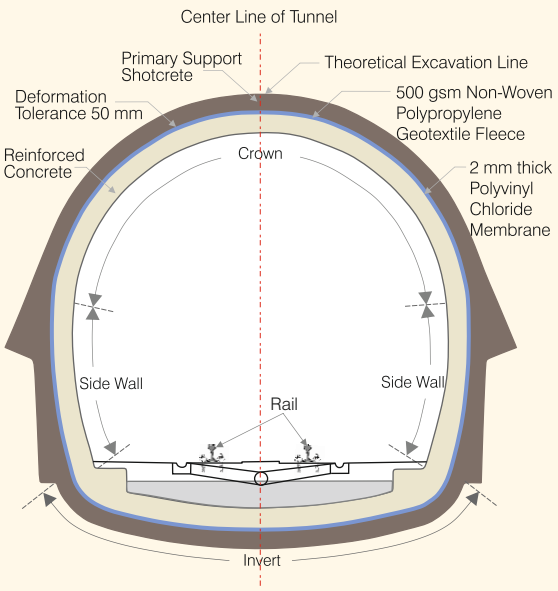
Specifications: The waterproof membrane shall consist of a continuous impermeable heat-welded PVC membrane sheet. PVC membrane shall have customized length equal to the perimeter of tunnel till benching excluding invert portion which is then thermos fused with the PVC membrane extended from the invert slab fixed to the rondels securing the geotextile to the PCC by mechanical fasteners.

Installation: Prior to application of the geotextile fleece layer the primary lining (shotcreting) shall be surveyed to confirm that it does not encroach into the designed extrados of the secondary lining and for inspecting sharp protruding elements from primary lining surface. In either case it shall be informed to the main contractor to bring it to the accepted levels to proceed with waterproofing. It shall be ensured that the shotcrete lining shall be constructed in a way that all bolts and anchors are fully covered with shotcrete of the primary lining. The surface shall be prepared in accordance with the manufacturer's instructions and shall be free from any protrusions like fibers etc. a smoothening layer which is fiber free may be needed to be applied to achieve the desired surface conditions fit for waterproofing system installation.

For PVC sheet, the profile of the substrate (tunnel surface) shall not have any irregularities that exceed a ratio of length to depth of 5:1 and its minimum radius shall be 200 mm. Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm. The substrate surface shall be free from protrusions or sharp edges which may lead to membrane puncture.

The groundwater penetrating through the primary tunnel lining shall be collected and drained by appropriate measures. This drainage shall be maintained throughout the membrane placing process, and shall be so arranged that excess water pressure behind the membrane cannot develop.

All shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0-8 mm), applied in a layer of 30 mm minimum thickness. A layer of protective geotextile shall be attached to the substrate by suitable non projecting fastening installed directly through the geotextile fleece. When fixing the geotextile fleece overhead, sufficient fixings shall be installed to ensure the fleece is in close contact with the substrate and is self-supporting.



Typical Cross-Section of NATM Tunnel

The 2 mm thick PVC membrane shall have a signaling layer (twin colour membrane with top surface as a light grey/off white/light blue etc and bottom surface as black), to give a visual indication of any mechanical damage, shall be provided on the exposed surface of the waterproofing membrane. The signaling layer shall be such that it does not adversely affect the seam welds.

The 2mm thick PVC membrane shall conform to the following properties-

Thickness	BS EN 1849-2	2.0 mm + 5%
Tensile Strength	BS EN 12311-2	15 MPa
Elongation at break	BS EN 12311-2	250%
Resistance underwater pressure	BS EN 1928 method B	5 bar 5s at 1 hour
Root Resistance	UNI CENTS 14416	No penetration
Tear Resistance	BS EN 12310-2	80 N/mm
Tensile strength of welded seam	BS EN 12317-2	Cracks occur next to the seam
Microbial Resistance	BS EN 12225	compliant
Fire rating	BS EN ISO 11925-2	E

Expert Speaks

This article is in continuation with the previous 'Expert Speaks', in February 2019, Volume 29.

Flat Search in Tokyo and TOD

Let us look at another scenario related to TOD in this issue. If one wants to find a cozy 1-bed-room flat in Mumbai, New York, Paris and Tokyo, one would access major websites for flat/apartment search. Here we can assess how those flat search websites are "transit-oriented". This is evident from the following table:

Table: Transit-Oriented Flat Search in Major Cities

	Mumbai	NYC	Paris	Tokyo
Explanation of metro access of each flat advertisement	✓	✓	✓	✓
Preference search by metro accessibility in advanced optic		✓	✓	✓
Preference search by metro accessibility in basic option				✓
Room listing bymetro lines		✓	✓	✓
Room listing by metro stations				✓

Ref. Mumbai: 99acres.com, NYC: streeteasy.com, Paris: paris-housing.com, Tokyo: suumo.jp

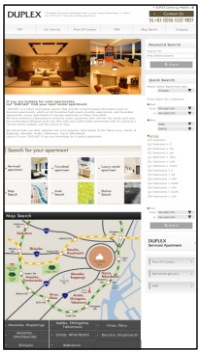
Tokyo is apparently unique. The web service in Tokyo offers transit-oriented index in the basic search preference and provides the real estate listing by each station as well as metro line. Paris and New York offer filters of accessibility to transit services but it is in the bottom of the advanced search options and just offer line-based listing. Paris geographically constitutes of 20 wards shaped like an escargot since 19th century and the flat search sites offer the listing by wards as people know characteristics of each ward. The search sites for New York offer the preference of doorman and pet availability.

Real Estate web search for Mumbai's does not offer transit-oriented preference. Mumbai's uniqueness of the search site was the Feng-Sui-Vastu compliance, power back-up and rain water harvesting. This quick assessment was done for English based sites and it is difficult to know whether local Hindi sites present such preference, however, it could be useful if all property advertisements in Mumbai show accessibility to transit service before completion of the Metro-3 Construction Project.

Above assessment can demonstrate that geographical spreading of habitation in Tokyo is incorporated into the transit network and stations, the ultimate status of TOD. Moreover, the flat search site in Tokyo offers a preference search by distance from the station, i.e. less than three minutes, five, ten, and more from station by walk. People then know, if it is closer, it costs but is convenient for access. If it is far from stations, it comes cheaper and inconvenient. Similarly, other flat search sites and several office/shop relocation websites for Tokyo are designed with transit-oriented preference, as companies know that good accessibility of office can attract more employees or customers from broader range. This is the real TOD mechanism, i.e., all property values are attributed to accessibility to transit services.

Under this kind of mechanism, properties in "station-front" in Tokyo comes valuable. The land owners of "station-front" properties invest more to cover the high property tax. The tenant in station-front must be posh and always renovated to recover its high rent. It will attract the new generated middle class to the "station-front" who hate traffic congestions. This is a reason why the traffic situation in Tokyo had to be improved.

Examples:



http://www.rental-apartment-tokyo.com/

https://www.sakura-house.com/en/B00220/1/room

Track Structure for Metro-3

Continued from Page 5

Safety – Lateral Deflections

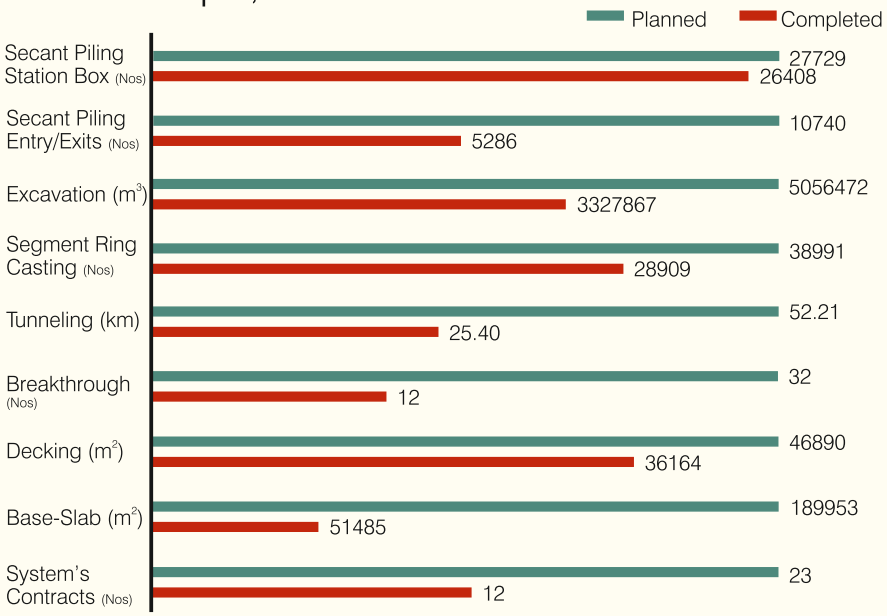
High vertical deflections are required to be taken into account of vibration reduction requirements. Therefore, vertical deflections can be permitted up to a certain degree. Similarly, deflections can not be allowed laterally. The booted twin block system is designed to provide vertical movements, however constrained horizontal movement. The pad underneath the block is very soft, much softer than the rubber that constitutes the boot. Therefore, vertical elasticity is governed by the pad, whereas lateral elasticity is extremely low because it is governed by the thin lateral layers of the boot. The block cannot easily rotate, because any local vertical pressure is controlled by lateral constraint of the boot.

News @ MMRC

Mr. S. N. Agarwal, IRSE, Member (Staff) Railway Board & Ex. Officio Secretary GoI along with railway officials visited Metro-3 tunneling site between Cuffe Parade and Vidhan Bhavan station. Dir. Project, MMRC briefed them about the technology used and the status of the project.

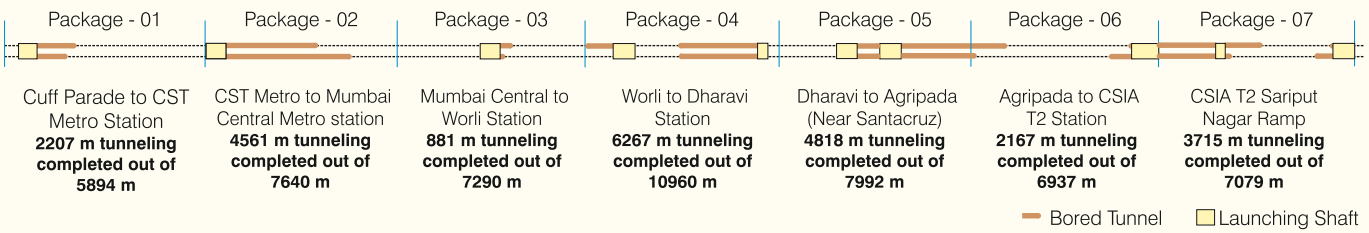
Cross passage construction work using NATM (New Austrian Tunnel Method) begins at Box A of Marol Naka Station. NATM is used to widen the station platform which is initially tunneled by the TBM. This 230 m long and 15 m wide Marol Naka Station will have 16 cross passages which will be constructed connecting Station box to the platform. Out of these, twelve cross passages will be used for public access and four for other services.

Project Progress Update
As on 30th April, 2019



MMRC opened steel deck for traffic movement from Kalanagar to BKC towards Kurla

Tunnel Progress Update As on 26th April 2019



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