



MMRC

ADDING NEW DIMENSIONS

# METRO CUBE

A MUMBAI METRO RAIL CORPORATION NEWSLETTER

## TBM - *The Game Changer*

Tunnel Boring Machines have revolutionised the tunnel construction industry in recent decades making underground excavation a more economical solution for creating underground space. The TBM technology has opened the possibility of creating tunnels where for a number of reasons including geotechnical, structural and safety reasons it was not feasible before.

Mumbai Metro 3 Project will deploy 17 of these TBM's to construct the 6.8m excavated diameter tunnel connecting Colaba in the south to Seepz in the north of Mumbai for a total distance of 33.5Km of twin bore tunnel. Additionally a number of World and National firsts will be achieved on this project including the use of 17 TBM's on a single metro line project.

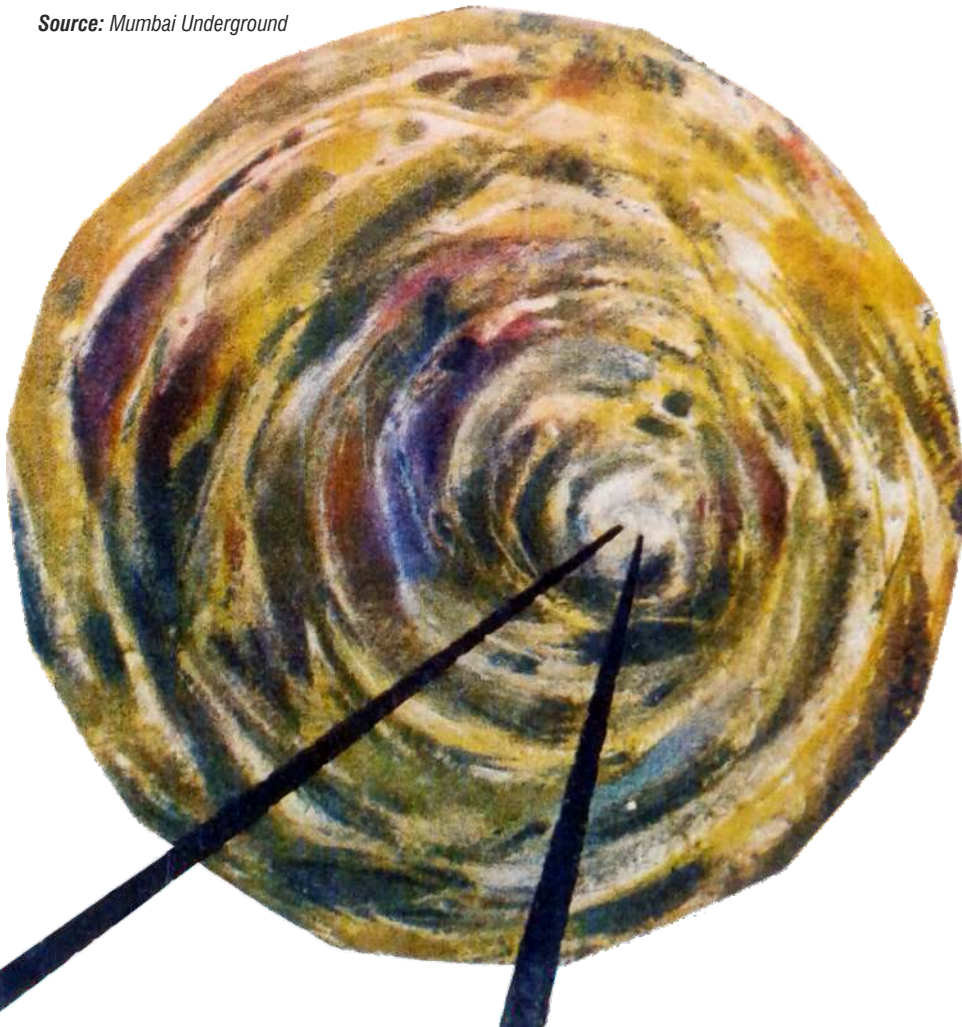
*Graphic illustration of an Underground Tunnel, designed by iconic poet, artist and graphics designer late Mr. Arun Kolatkar, on the cover of 'Underground Railway for Bombay - Some Thoughts' by Dr. P. G. Patankar, 1963*

**Source:** Mumbai Underground



## ANNIVERSARY ISSUE

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# MD Speaks

Ms. Ashwini Bhide, IAS



It gives us immense pleasure to take note of completion of one year of an eventful journey by METROCUBE. It is a matter of pride and satisfaction in bringing this anniversary issue in a new format. METROCUBE started its baby steps in September 2016, as a humble initiative of information

dissemination on project development and help generate a positive public opinion on the Metro Line 3. This initiative by the Team Metro 3 soon received encouraging response from all reader groups on the content mix, objectives, focus of various details and an inclusive approach under citizen/expert speak section. The intent of reaching out to more citizens of Mumbai, wider cross-section of readers and interest groups from rest of India and World will continue to keep this METROCUBE team fully engaged in future.

Although, MMRC as a JV-SPV of Govt. of India and Govt. of Maharashtra has completed only 3 years, the project journey started in 2010 with planning for fully underground Metro System for Mumbai. While the field activities started in July/August 2016, the journey thus far has not been an easy one. The effort made by MMRDA, its officials and professional inputs from various consultants, stakeholders is noteworthy to be recognise in making of Metro Line 3.

With due regards to all the multi-disciplinary professionals involved, the project Metro 3 has now surpassed major hurdles of environmental clearances, rehabilitation and resettlement and transfer of government land. The process of acquisition of private land, in-situ rehabilitation of occupants on private lands and title holders at Kalbadevi - Girgaon has been streamlined. All required statutory clearances including change of land use for the Metro Car Depot at Aarey, NGT clearances and issues in shifting the HT lines and pylons are sorted out successfully to clear the way for depot construction at Aarey. Subsequently, the Depot Civil Works contract is awarded to get the work rolling.

Almost all Tunnel Boring Machines (TBM) have been cleared in the Factory Acceptance Tests (FAT) and 4 of them have already arrived in Mumbai. With launching shafts nearing completion the tunneling work in all sections

will be started by March 2018. The underground station construction work will gear up soon as majority of utility shifting getting completed and secant piling activity is in progress.

Certain apprehensions being raised by the residents and institutions in South Mumbai are being addressed with the help of Hon'ble. High Court by involving experts in the field. It was demonstrated that works in heritage areas are being carried out following the international protocols and the High Court appointed committee has expressed their satisfaction on procedures adopted.

Simultaneously the procurement of System components is also progressing at steady pace and the priority contracts are about to be awarded in the next 3 months. That gives the confidence that the MMRC as an organization is fully gearing up for the delivery of the project as per committed schedule in 2021.

We also appreciate and acknowledge the efforts and cooperation extended by the State Govt departments, MCGM, Traffic Police and innumerable stakeholders and citizens of Mumbai in reaching the present stage. At this moment, MMRC requests for full cooperation and patience from the Mumbaikars to cope with the limitations posed by citywide construction zones. This is a necessary hardship to be faced by the city in delivering the mega-project of this size and complexity. Our technical team and experts will continue their dedicated efforts on the project delivery and help mitigate the challenges faced.

MMRC website, Facebook, Twitter handles and this newsletter are the media for us to engage with citizens and public at large. From this month, onwards for the convenience of Marathi speaking stake holders, METROCUBE will also be available in Marathi. MMRC will continue with the endeavor of information outreach and address project specific grievances through active interaction and build mutual confidence and trust to proceed together in reaching the destination Metro 3.

A constant confrontation by print and electronic media has so far help us improve our actions and project implementation process. Team MMRC assures to continue with committed efforts in the coming year in realizing the dream called Metro Line 3 and creating a new public transit for this Great City!

# Project Status

The MML-3 Project is divided into 18 main packages of 'Civil Works' and 'System Components'. Pre-Qualification of civil contractors was conducted on 9th September, 2014. After the Pre-Qualification and negotiations with the shortlisted bidders, the Civil contracts were awarded to the qualified bidders on 18th July 2016. Pre-qualification (PQ) of all the system packages was completed and PQ bids for tracks are under finalization. Contract packages under JICA funding are awarded and managed as per JICA procedures, while the non-JICA funded packages are awarded following the procedures of EPC Contracts.

Metro 3 is the first project of its kind, one of the most challenging mega urban infrastructure projects in India, with the metro alignment penetrating through the busy business district of South Mumbai, heritage and institutional areas, dense neighborhoods of Girgaon-Kalbadevi, mix residential and commercial districts of central Mumbai and domestic - international airports. Besides the technological challenges imposed by Mumbai's geography, geology and urban setting, the challenges to create a smoother interface and coordination within the communities around the construction sites and within different social groups are of an intense gravity. Most of such challenges arise out of strong public opinions shaped by influential social entities and they need to be dealt with patience and optimism. Media plays an important role in shaping and changing such public opinions and MMRC's constant endeavor to create awareness within people through media has proven to be in the right direction.

The project encountered delays on account of earlier stay on tree cutting, restrictions on work from 10 pm to 6 am, concerns raised by J N Petit Trust and other activists groups. However, MMRC intends to resolve all such matters through legal and experts' advice. In spite of such on going constraints, we are committed to accomplish the project delivery by 2021 as per schedule, with engagement of additional resources through the contractors.

Factory Acceptance Tests (FAT) of 12 TBMs are completed successfully and for the remaining five TBMs will be completed shortly. All the TBMs manufactured by Terratec, Robbins and Herrenknecht will start operating within 4 months.



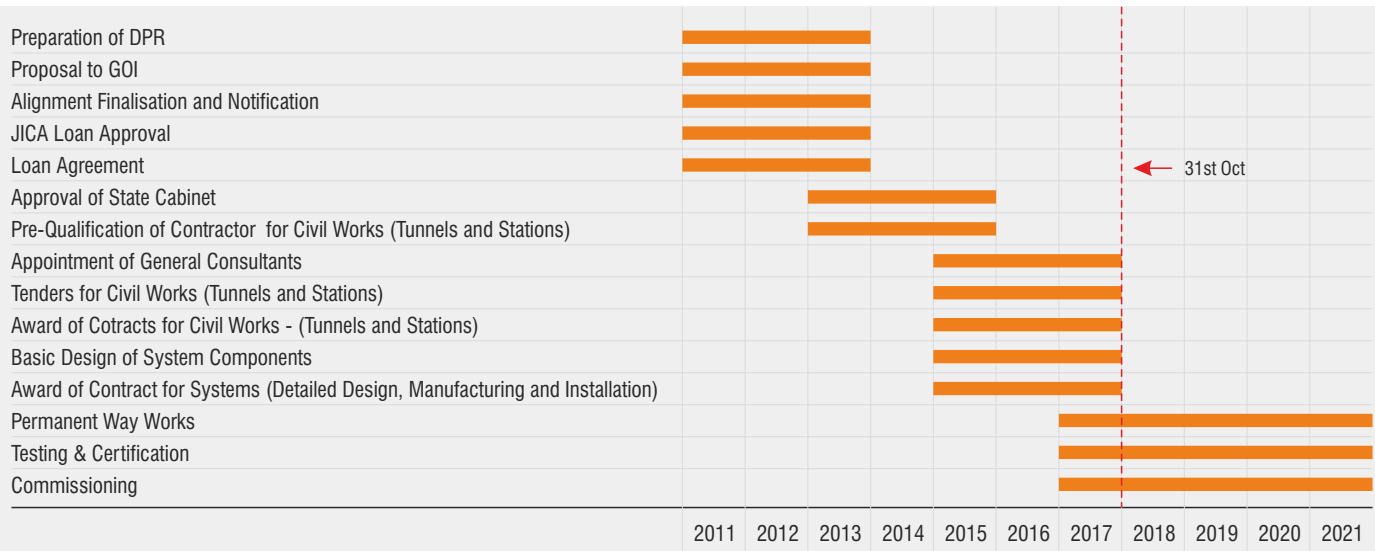
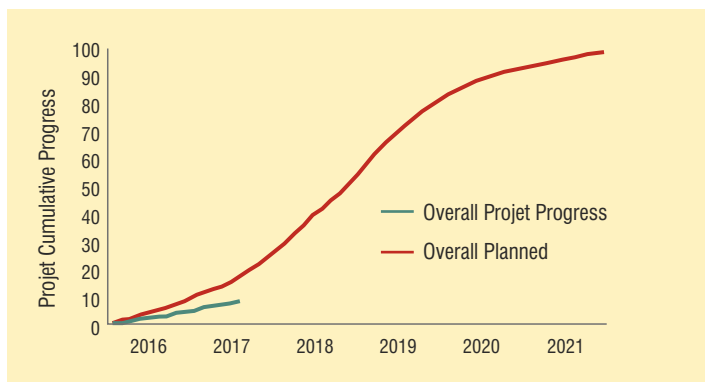
TBM-UGC 03



TBM-UGC 04



TBM-UGC 05



Project Status and Implementation Schedule as on October 2017



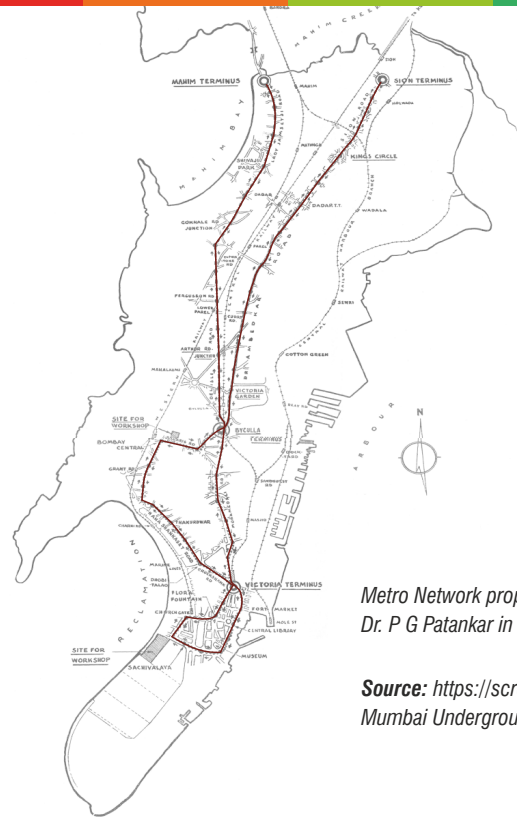
# Looking in the History

According to early records from the Indian Railways, an underground mass transit proposal was carved out by a British Town Planner W R Davidge way back in 1920s, connecting the business districts of Fort to Sion-Mahim with provisions to extend further North in the suburbs. The proposal came up sixty years after opening of London Metro in 1863. It is evident that the need of a mass transit system for Mumbai was foreseen by the Planners and Railway Engineers since then.

Further in 1960, plan for an underground Railway System in Mumbai was commissioned by the State Government, which was drafted by Dr. P G Patankar, an Engineer and Railway Expert. Dr. Patankar envisioned five inter-connected underground Metro lines for the island city of Bombay, whose local trains and buses were already overburdened by a burgeoning population. The report was submitted to the State Govt. in 1963.

In January 1996, seven companies including Tata Consultancy Services came together to form the Mumbai Metro Planning Group (MMPG). An expert committee led by Dr. P G Patankar was setup under the leadership of MMPG to prepare a feasibility study for a metro rail in Mumbai. The report was drafted and delivered in the year 1997.

Mumbai Urban Transport Project initiated by the Govt. of Maharashtra with an intention to provide efficient, comfortable and affordable transit to Mumbai was a milestone initiative which led to realization of several urban transport projects for Mumbai including the Mumbai Metro. It began with inception of Metro Line 1 in 2006 followed by the Metro Line 3 in 2010.

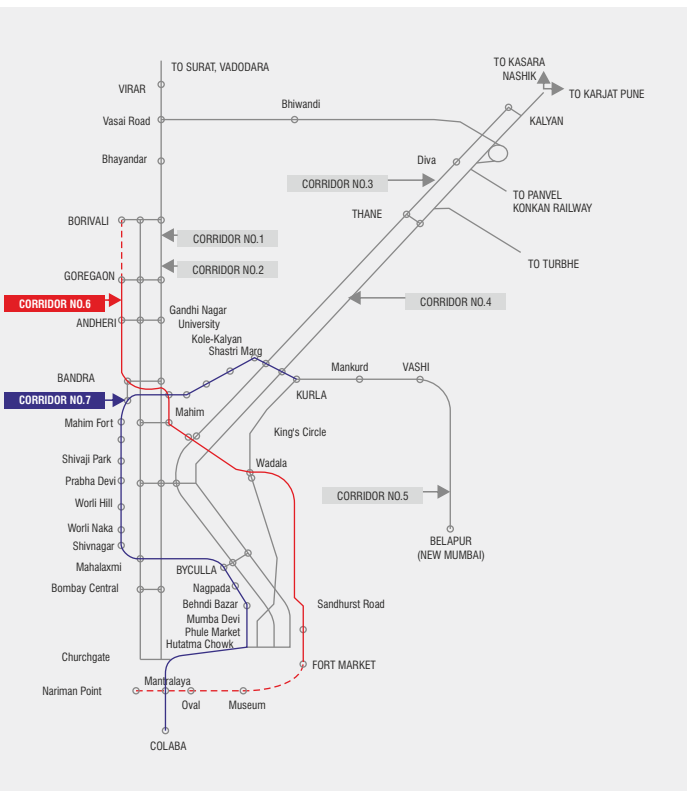


*Metro Network proposed by Dr. P G Patankar in 1963*

**Source:** <https://scroll.in> , Mumbai Underground

## Other Railway Initiatives

- Indian Railways established Metropolitan Transport Projects (MTP) in 1969, to augment existing 5 Sub-Urban rail corridors in Mumbai
- 2 new Metro Corridors were Identified & Feasibility report in 1979;
  - 6th Rail Corridor; Fort Market-Wadal-Goregaon
  - 7th Rail Corridor; Colaba-Bandra-Kurla-Airport
- Mumbai Metro Planning Group (MMPG, a consortium of TCS, CES, Autoriders, Lok Housing, PB & Construma) prepared feasibility report and suggested implementation of 7th Rail Corridor as Metro Rail system 1997



- 2002** Conception of MUTP under MMRDA
- 2003** MMRDA initiated Mumbai Metro Master Plan
- 2004** Mumbai Metro Master plan prepared by DMRC  
Public Consultations held and approved by MMRDA and State Govt.
- 2006** Metro Line - 1 awarded on PPP
- 2008** Metro Line - 2 awarded on PPP
- 2011** Metro Line 3 initiated on EPC model with JICA funding  
Mumbai metro Line 3 alignment published for Suggestions and Objections
- 2012** Public Consultations held
- 2013** Govt. of India approved project with JICA funding  
Metro 3 alignment notified under Metro Act (2009)  
JICA Loan Agreement signed
- 2014** Govt. of Maharashtra approval

# Mumbai Metro Masterplan

With an objective of improving traffic and transportation scenario in Mumbai Metropolitan Region, MMRDA appointed M/s. Delhi Metro Rail Corporation (DMRC) (assisted by TATA Consultancy Services-TCS and Indian Institute of Technology-IIT, Mumbai) in May, 2003 to prepare Mumbai Metro Master Plan.

The Plan has been prepared to provide a rail based mass transit facility to people residing in the areas which are not connected by existing Suburban Rail System so as to enable them to avail efficient transit and connectivity.

The plan consists of 172 km of rail network configured under 9 North South and East West corridors. The system provides connectivity to important stations like Churchgate, Chatrapati Shivaji Terminus, Mumbai Central and International & Domestic Airports and major business hubs with planned interchanges with major Suburban Stations. The network is also extended to the new development nodes in outskirts of Mumbai like Kalyan, Bhivandi to provide faster connectivity with the city.

After implementation of Mumbai Metro Master Plan, more than 70 lakh commuters are expected to get benefit which in turn will substantially reduce the traffic on road and congestion in suburban rails.



Mumbai Metro Masterplan

## Making a Walkable Metro

With the new 172 km long metro network planned in a short span, it is important that it gives the city full value for the investment incurred. Besides offering, speedy, comfortable and frequent services to-from several destinations, it should offer a qualitative value to the daily commute, making the journey to and from the stations- whether existing suburban or new metro or even bus stations- easier, faster and safe.

It is a well recognized principle of mobility that most people (except the very old or sick) should walk a distance up to 1 to 1.5 km to reach any public transport mode within 8 to 15 min. This is too short a distance to use car, auto or taxi. This much walking is necessary for the health of people and the city. This will also eliminate the need for providing taxi/auto stands or parking areas around the metro stations and bus stops. If this cost is eliminated, it is possible to justify an increase in Metro fare to reduce the need for subsidy.

Metro III appears to have a well laid alignment in relation to western railway. Most areas west of suburban railway network are bisected by Metro III in the island city so that impact area of Western Railway and metro complement each other. On the other hand, in the western suburbs, the Metro III traverses in the east of western railway and offer the same benefit of

making both Metro and Western Railway network within walking reach of large populations.

If we map the impact areas around station locations (i.e. within an inner radius of 1 km and outer radius of 1.6 km from each metro and railway stations to identify accessibility by walking), one can realise that walkability can be improved through better and inviting footpaths and pedestrian environments.

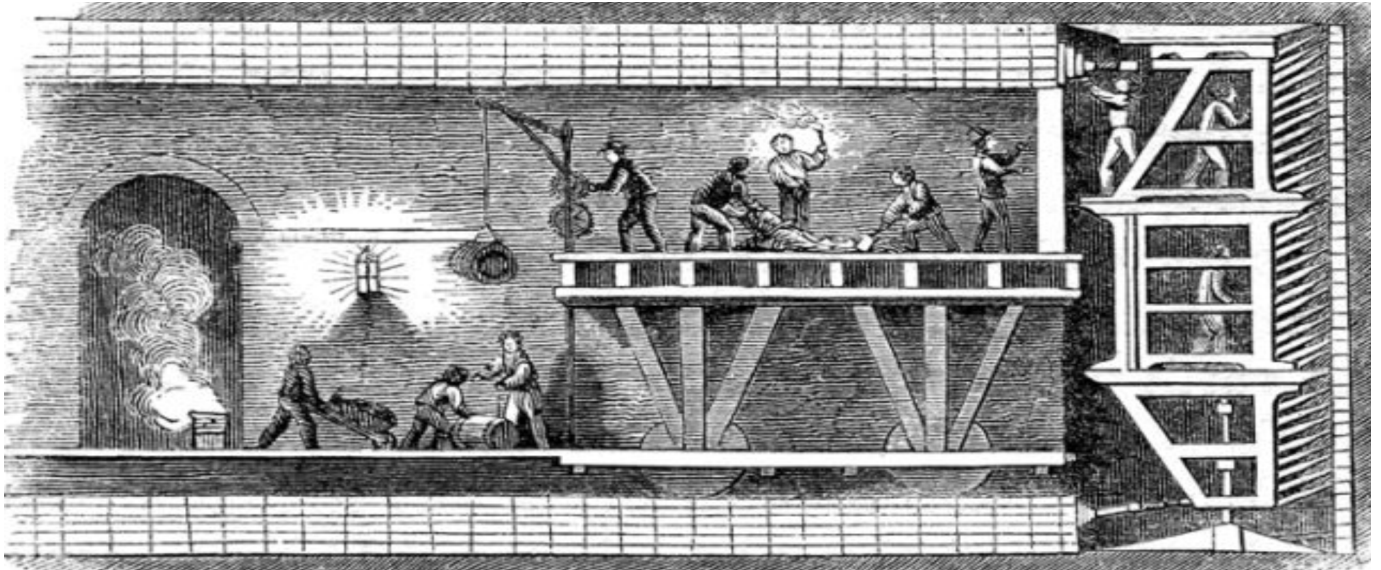
A comprehensive, multi layered and intelligent mapping of existing and future transport networks will help improve the overall transport efficiency as well as traffic calming and health of people. This kind of balanced approach to transport network can definitely discourage personal transport through regulated and fairly priced parking and can help creates space and users for public transport networks.

**Mr. Ashok Datar**

*Mr Ashok Datar is an urban transportation and solid waste management expert, active in Mumbai for over 15 years. He was the founder member of an alliance of all traffic analysts and activists in Mumbai called 'Mumbai Transport Forum' and is a member of various committees appointed by Hon High court and the GOM.*



# Evolution of TBM Technology



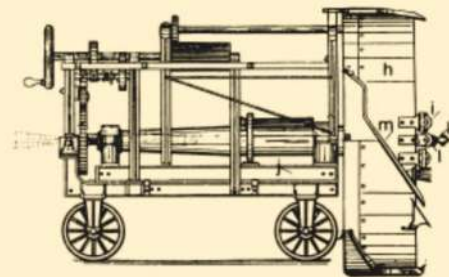
*Brunel Shield - Concept to Mechanised Tunnelling*

## History of Tunnel Boring Machines

The history of TBM's for constructing tunnels goes back to 1825 when the concept of a shield to support the rock was first introduced into tunnelling by Sir Marc Isambard Brunel who constructed a tunnel under the River Thames in London. Although excavation of the rock was done by conventional

means namely drilling and blasting, Brunel developed the concept of continuous excavation and ground support using shields. This paved the way for the development of the modern TBM.

Although the Brunel shield laid down the concept of mechanised shield tunnelling, it however did not address excavation of the ground by mechanical means. This development is attributed to a Charles Wilson of the United States who in 1853 developed a mechanical cutting device for the construction of the Hoosac Tunnel in Boston. The machine drilled a total length of 3.0m (10 feet) into the rock before breaking down.



*The Charles Wilson TBM with Rotating Cutters*



During the late 19th and early 20th century, inventors continued to develop upon these two basic principles, namely utilising a shield with circular rotating cutting head to excavate tunnels. These developments were in direct response to the global demand for tunnels to overcome natural obstructions such as mountains, rivers and densely populated areas namely for railroads, sewers and the supply of water to urbanised regions and cities.

Advancements in metallurgy (Study of metals), developments in hydraulics, pneumatics and electricity (Essential elements in modern TBM's) and a better understanding of earth sciences (Geotechnical Engineering) led to a rapid development in the design of TBM's. However the basic concept developed by Brunel and Wilson still remain in these modern underground excavation machines known as TBM's.

### **Two of the modern TBM's to be used on Mumbai Metro Line 3 Project.**

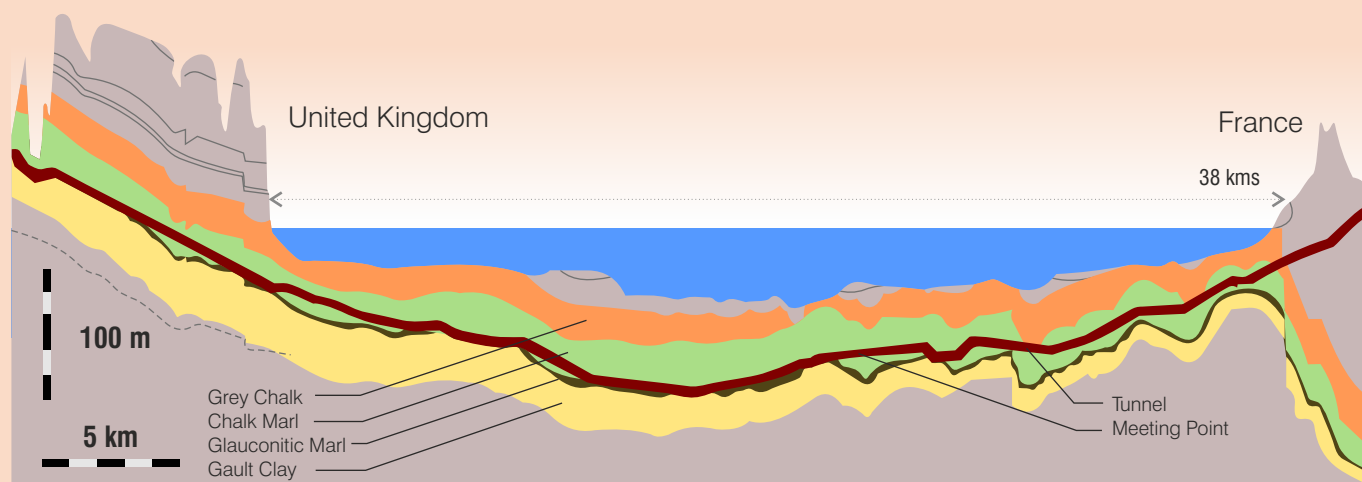
*Picture Left-1 is the 6.6m Diameter Terratec Dual Mode Hard Rock Machine purchase by J Kumar to construct tunnels between Vidyanagari and Santa Crus Stations.*

*Picture Left-2 is the 6.62m Herrenknecht EPB TBM purchased by HCC to construct tunnels between Sidhivinayak and Worli Stations.*

## International Examples of Other TBM Projects

There are many famous international tunnel projects where TBM's have been used but none more so than the Channel Tunnel Project in the UK, a 38Km 8.8m diameter undersea tunnel. A major tunnel challenge at its time. Some global civil engineers believe this to be the second most successful human engineering endeavours to putting a man on the moon. Like

travelling to the moon, most tunnellers and engineers were travelling blind and with the technology available at the time (1990) many thought it would never be completed. However although 12 months behind schedule and INR 85,146,000,000 over budget, it is still believed to be the jewel in the crown of tunnelling achievements.



*Cross Section of the Channel Tunnel 38Km Crossing*

## TBM Tunnel Excavation - Challenges in Mumbai

Urban tunnelling, like here in Mumbai has special requirement that the ground surface must remain undisturbed if key structures like buildings, temples and bridges are to be prevented from damage. This means that ground subsidence must be avoided.

In soft ground conditions, the normal method of doing this is to maintain the soil pressures beneath the structures intact during and after the tunnel construction. There is some difficulty in doing this, particularly in varied strata e.g., boring or excavating through ground where the upper portion of the tunnel face is wet or soft and the lower portion is hard rock which is typically the case in Mumbai.

TBM's with positive face control, such as EPB and Slurry machines, are used in such situations and indeed are 2 of the three main TBM types used on the MML-3 Project. Both the EPB and Slurry TBM's have been chosen and are capable of reducing the risk of surface subsidence and settlement if operated properly. This will be the main challenge here in Mumbai. Additionally well documented ground conditions ahead of the TBM, continual monitoring of structures and

ensuring good TBM tunnel practice the group of Engineers employed by MMRC will ensure excavation is completed successfully with minimal risk to people, buildings and other infrastructure here in Mumbai.

As briefly stated, the project will accommodate measures to mitigate any detrimental effects to other infrastructure. Subsidence is not the only problem when it comes to tunnelling in an urban environment. Additional critical failure events such as face instability, collapse and large deformations of either or both excavation or its lining can lead to undesirable consequences such as injuries or loss of life, damage to third parties, additional costs, and delays in completion of the tunnel project. MMRC in collaboration with specialist consultants, engineers and contractors have put in place a suite of measures to ensure operational safety, mitigate delays to ensure successful completion of the job. This has been implemented since day 1 of project commencement and is an ongoing activity with continual assessment. A huge challenge on a project of this magnitude but one which is proving successful.



# Clean Development Mechanism

The Clean Development Mechanism (CDM) was established in Article 12 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). The purpose of CDM is to assist developing countries in 'achieving sustainable development'.

CDM projects (like Metro rail projects) are an alternative to existing modes of transport such as buses, taxis, passenger cars, automatize three & two wheelers which has serious effects on urban eco system due to congestion and emission of greenhouse gases and other air pollutants. The metro rail has resulted in passenger ridership shift from road based transport to metro. It improves the resource efficiency of transport passengers because emissions per passenger kilometer are reduced compared to a transport situation without a metro. Improvements in the environment are achieved through less GHG (greenhouse gases) and other air pollutant emissions, specifically Particulate matter, SO<sub>2</sub>, NO<sub>x</sub> and HC.

However, the implementation of metro rail system requires huge investment and puts burden on developers to arrange for the investment funds. In such scenario CDM revenues are beneficial. The CDM projects can earn saleable Certified Emission Reduction (CER) credits, each equivalent to one ton of CO<sub>2</sub>, which provides fund resources to the project and can be counted towards meeting Kyoto targets of reducing greenhouse gas emissions.

Metro 3 is entitled for CDM benefits under United Nations Framework Convention on Climate Change. To avail the CDM benefits, MMRC with assistance of Delhi Metro Rail Corporation (DMRC), intends to include the Programme of

Activities (PoA) approach that DMRC has initiated. The DMRC has registered MRTS- PoA-9863 as a Clean Development Mechanism project with the CDM Executive Body of the UNFCCC. The MRTS PoA in India is being managed by DMRC as a coordinating and managing entity, which act as an umbrella organization for all MRTS CDM projects in India.

The process of estimating the emission reduction in terms of CO<sub>2</sub> equivalent by MML-3 project has been initiated through DMRC. The baseline emission without Metro 3 project and project emissions are estimated. The baseline emission include the emissions that would have happened due to the transportation of passengers who use the project activity, had the project activity not been implemented. This is differentiated according to the various modes of transport that the passengers would have used in the absence of the project.

The project emissions are based on the fossil fuel and/or electricity consumed by the MRTS (direct project emissions) plus emissions caused by project passengers from their trip origin to the entry station of the project and from the exit station of the project to their final destination (indirect project emissions). The emissions due to leakages and change in load factor are assumed negligible.

The ex-ante estimate of reductions in crediting period of Ten years is 26,17,067 ton of CO<sub>2</sub>e. The annual average reduction over the crediting period starting from the year 2021 is 2,61,707 ton CO<sub>2</sub>e. MMRC has already completed on site validation by the Designated Operational Entity (DOE) in the month of October 2017 and further process is likely to be completed by December 2017.

## MMRC Control Room

Contact us @ 8291751545 to report monsoon related grievances pertaining to Metro-3 construction work.



Website Link

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