Water supply through underground tunnel from Thane to Bhandup using TBM

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Abstract: - *The existing pipelines in Mumbai are 100 year old and they are above the Earth surface so there were orrosion and safety issues due to salty water and high humidity. Also expected population of Mumbai till 2021 will be 163.5 lakhs and till 2051 will be around 200.43 lakhs so there will be a need of more water supplies hence broader water pipelines are needed for fulfilling future demands. For meeting all these problems underground water supply tunnel is constructed.*

Key words: **pipelines, corrosion, population, tunnel.**

1. Introduction:

Taking into consideration the growing water demand the water supply department of MCGM proposed the project of underground water tunnels for safe transportation of water. This project was passed by the standing committee of MCGM. Later tenders were invited and its awarded to 'UNITY Infra-IVRCL' on joint venture basis. The project will prove to be a boon for the city as water is brought from the source to Bhandup plant through a network of water mains, viz., Vaitarna, Upper Vaitarna, Tansa East and Tansa West. These mains, which have been carrying water, are more than 50 to 90 years old.

The thickness of these pipelines has reduced due to wear and tear, thereby causing frequent bursts. Hence it was necessary to replace them. The water supply network in the city is also old. Development works in the city as also encroachments have led to burial of water pipelines below roads and infrastructure at various locations. Due to old and dilapidated pipelines there have been frequent occurrences of bursts and leakages leading to frequent repairs. Sometimes, it becomes difficult even to approach such buried pipelines in case of repairs.

Considering all the above facts, BMC has undertaken this massive project of supplying water through underground tunnel from Kapurbawdi (Thane) to Bhandup water treatment plant.

2. Methodology:

The joint venture (JV) of Unity Infraprojects and IVRCL Infrastructures & Projects has bagged a Rs.1,145.88 crore contract from the Municipal Corporation of Greater Mumbai (MCGM) to construct a 8.3 km long tunnel from Kapurbawdi to Bhandup complex. Construction work has already started on the crucial project, one of the deepest raw drinking water tunnel in Asia. The unique feature of this project is the use of a Tunnel Boring Machine (TBM) for excavation which will reduce the project execution period drastically from five years to 18 months.

Although Mumbai city quenches its thirst through six lakes, the ever increasing population of the city, bursting in its seams, demands more water than what is supplied, creating a considerable demand supply gap. To meet the water demand of Mumbai City by 2031, MCGM has proposed to develop Middle Vaitarna, Gargai and Pinjal Water Sources as per the directives from government of Maharashtra. Middle Vaitarna project is underway and will yield 455 MLD after completion whereas Gargai and Pinjal sources will be commissioned by 2019 and will yield 455 MLD and 697 MLD of water respectively. So the total supply will be increased by 1607 MLD to 5275 MLD (million liters per day).

To supply this additional water from these water sources to the Bhandup complex a deep water tunnel will be constructed by a joint venture (JV) of Unity Infraprojects and IVRCL Infrastructures & Projects from Kapurbawdi to Bhandup complex.

Kapurbawdi is situated in northern part of Mumbai city in Thane district and Bhandup complex is situated in Mumbai city near Mulund. The area between Kapurbawdi & Bhandup is a highly dense populated area consisting of various high rise buildings. Kapurbawdi and Bhandup mark the length of the tunnel. (Fig 1).

Fig 1: Alignment of tunnel from Kapurbawdi to Bhandup.

This underground RCC structured tunnel is earthquake resistant and prohibits all possibilities of water theft, contamination and corrosion. For technical reasons RCC is used for lining of the total distance from Thane to Bhandup as it has the capability to withstand the massive pressure of water at the depth and enhance the life of the tunnel for a longer period of time. The length of the tunnel is 8.3 km i.e. from Kapurbawdi in Thane which is the inlet side of the tunnel - having 11.8 m diameter to reach a depth of 108 m. At the outlet at Bhandup, the diameter will be 11.8 m and the depth 125 meters (equivalent to a 40 storied building).

2.1 Scope of work:

- Surveying for fixing location of shaft and alignment of tunnel between the shafts.
- Construction of vertical shafts by conventional drilling and controlled blasting method as listed below:

Table 1: Shaft diameter and depth.

Sr No.	Location	Finished dia	Depth
1.	Kapurbawdi	11.8	108m
2.	Bhandup	11.8	125m

- Excavation of tail tunnel, assembly tunnel and dismantling areas, at the bottom of shafts, by conventional drilling and controlled blasting method.

Table 2: Length of Tail Tunnel and Assembly Tunnel.

Sr No.	Location	Tail Tunnel	Assembly Tunnel
1.	Kapurbawdi	50m	100m
2.	Bhandup	10m	20m

- Boring of tunnel of 6.25 m diameter by a modern full face TBM including communication facilities, safety measures, lighting, ventilation, dewatering, wet/dry mucking and its disposal.
- Probe hole drilling, pre grouting with cement and post grouting with cement or chemical to control seepage of sub soil water.
- Dismantling of TBM and withdrawal of the same through shaft. Reinforced concrete tunnel lining of size of 5500 mm finished diameter.
- Provide concrete enforcement to the pipes in shaft, anchor bolts etc.

2.2 Salient features of Project:

- Construction of vertical shaft within the well of finished diameter of 11.8 m and the depth of shaft is 108m at Kapurbawdi and 125m at Bhandup from the ground level with the help of controlled blasting and conventional drilling.
- Excavation of tail tunnel and assembly tunnel by controlled blasting and conventional drilling.
- Boring of tunnel of 6.25 m diameter by a modern full face TBM including communication facilities, safety measures, lighting, ventilation, dewatering, wet/dry mucking and its disposal.
- Reinforced concrete tunnel lining of size of 5500 mm finished diameter.

3. Why TBM?

The total length of the tunnel from Kapurbawdi to Bhandup is 8.286km. The alignment is passing through the populated area of Mumbai city with existing old/new and high-rise structures. The duration for the project is only 60 months. So because of the short duration and the alignment is in highly populated area so drilling and blasting cannot be used. The monthly progress required for this project is min. 500m and it is achieved only through the tunnel boring machine. So TBM is being used.

3.1 Why hard rock TBM?

Tunnel boring machines are mainly applied on hard rock, while shield machines are basically used in soils. A hard rock TBM is suitable for application in a rock mass in which a support of the excavated cross section in the area of the temporary face and of the machine is not required or may be achieved with minor efforts, e.g. rock bolts, steel sets and Shotcrete, applied at the roof of the tunnel.

Here in this site the strata was very hard, it is hard rock. Type of rock is hard blackish basalt. So hard rock TBM was used.

3.2 Functional Principle of TBM:

Characteristic for a TBM is the excavation of the ground with a rotating cutter head, which is equipped with rolling cutters (discs) and is pushed against the temporary face by the thrust cylinders. The rolling movements of the discs on the temporary face cause fractures in the rock creating chips to break away from the temporary face.

Buckets, which are mounted at the periphery of the cutter head, scoop up the chips and deposit the muck via deflectors onto a belt conveyor. The muck is then transferred to the conveyor of the machine for removal from the tunnel.

3.3 Overview Tunnel Boring Machine:

The tunnel boring machine consists of cutter head, main bearing, shield, main beam, gripper carrier. This is main part of TBM. Cutter head is driven by 7 electric motors, it includes 1 break motor.

All motors are controlled by specialized VFD drive. Back side of TBM, backup system is installed which consists of wet Shotcrete system, LT & HT transformer unit, HPU (hydraulic power pack unit), De dusting unit (Scrubber), rescue chamber, advancing tail ace, booster fan. All equipments are must for the operation of TBM.

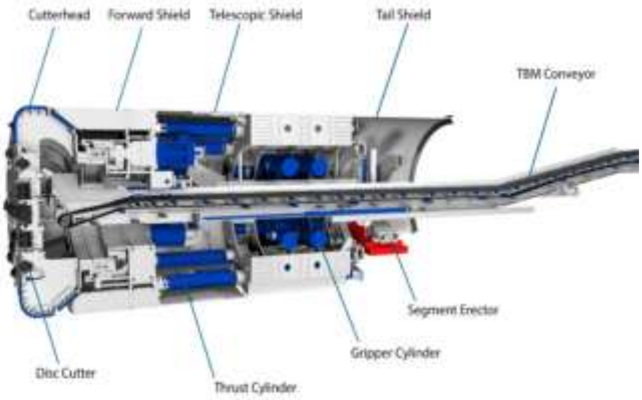

Fig 2: Components of TBM (source: Robbins TBM)

4. Laser Target:

- Laser system is fitted behind the TBM for the guidance of alignment for tunnel. Bored diameter is 6.25m so the centre line of tunnel is at 3.125m.
- Laser target surface area is 450 x 200 mm.
- Laser system is fitted with the channel section on the tunnel with the bolt and nuts.
- From the Kapurbawdi to Bhandup the tunnel is being constructed with the rising gradient of 1:750.
- So the laser gradient is set at 0.0013. It means that for 1m in length the tunnel is going up for 1.3mm.

5. Conclusion:

Water supply network in the city is old. Development works in the city as also encroachments have led to burial of water pipelines below roads and infrastructure at various locations. Due to old and dilapidated pipelines there have been frequent occurrences of bursts and leakages leading to frequent repairs. Sometimes, it becomes difficult even to approach such buried pipelines in case of repairs. Tunnels are designed as earthquake resistant structures and have a life of 100 years. Need minimum maintenance. Tunnels begin 60 to 100 meter deep below the ground and avoid losses due to thefts, leakages. Thus they play a major role in reducing the percentage of Non Revenue Water (NRW) and help reduction in contamination. Also, they do not require expenses on account of land acquisition and rehabilitation. Tunnels operate on gravitational flow and thus do not require additional cost for pumping of water. Mumbai's dense population, heavy road traffic as well as the large network of underground utilities makes it extremely difficult to lay new water mains of large diameters by open trench method. This makes tunnels the best option as TBM helps to execute the work at a fast rate and with minimum hindrance to the daily life of cities likes Mumbai.

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