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WATER SUPPLY TUNNEL PROJECT USING TBM

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Abstract- Water is a basic prerequisite for any life on earth. From ancient times, man placed his permanent settlements only on locations, where water was available during the whole course of the year. Along its evolution, mankind learnt to utilize water in multiple manners, for its needs and benefits. As the early settlements grew to cities, the demand for potable as well as industrial water rose in analogy to their populations. Soon, the available water resources of the urban areas did not satisfy the requirements of the citizens any more. The communities began to search for water resources outside of the city limits and with the rising demands the distances of conveyance elongated. Thus, since ancient times, the design, construction and operation of artificial water supply systems for the big cities is amongst one of the most interesting assignments of civil engineering and, quite often, either of tunnelling.
Keywords- Water supply, population, Mumbai, TBM

I. INTRODUCTION

Mumbai, with its population of 21.3 million, is one of the most densely populated and rapidly growing cosmopolitan areas in the world (Fig.1). The construction of the city's municipal water supply system started already as early as 1860, and since then has been expanded step by step, according to the rising demands of the city.

Today, the metropolis owns a widely spread network of more than 300 kms of primary transmission system, supplying its citizens with 2.950 MLD (million litres per day) of potable water from mainly 6 water reservoirs (Vihar, Tulsi, Tansa, Modaksagar (Lower Vaitarna), Upper Vaitarna and Bhatsa). By that, Mumbai's municipal water supply system ranks among the eight largest of the world. Despite that, during the following years it will be necessary, to even increase the supply and upgrade it for a daily consumption rate of more than 6.000 million litres, expected in 2021.

Hence the herculean task of construction of water supply tunnel from Kapurbawdi to Bhandup water treatment Complex was undertaken by MCGM. (Municipal Corporation of Greater Mumbai).

II. METHODOLOGY

The existing pipelines in Mumbai are 110 year old and they are above the earth surface. As result of which there are corrosion and safety issues due to salty water and high humidity. Also with increasing population of Mumbai there will be need of more water supplies so broader water pipelines are needed for fulfilling future demands. The space occupied by existing pipes can be used for different purposes. For meeting all these problems underground water supply tunnel is constructed. 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. 2)

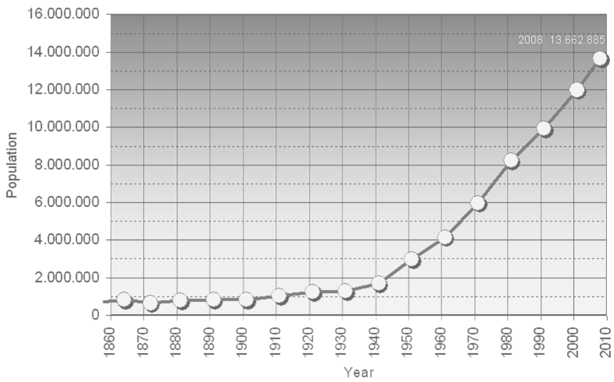

Fig.1. Mumbai's population growth

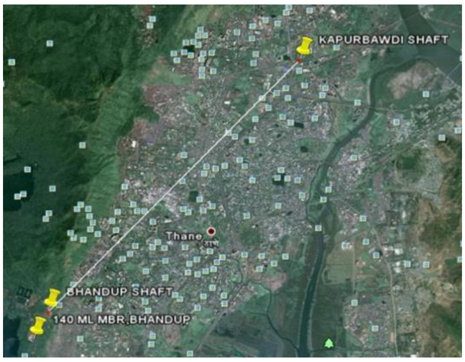

Fig. 2 Alignment of tunnel

III. PROJECT OVERVIEW:

A. *Objectives of project:*

To fulfil the water supply demand in a safe and uninterrupted manner in future. This program includes:-

1. To construct the 11.8m diameter 108m deep inlet shaft at Kapurbawdi
2. To construct the 11.8m diameter 108m deep inlet shaft at Kapurbawdi
3. To bore 6.25m diameter 8.3 km long tunnel from Kapurbawdi to Bhandup with effective diameter 5.5 m of pipeline to be passed.

   Entire project lies in seismic zone III

B. *Scope of work:*

1. Construction of rock tunnel as shown in Fig. 3 using Full Face Hard Rock tunnel boring machine(TBM), of length 8.3km (between Kapurbawdi and Bhandup water treatment complex). The bored diameter being 6.25m and RCC lined diameter being 5.5m.
2. Construction of inlet shaft at Kapurbawdi of 11.8m diameter, 108m deep inlet shaft at Kapurbawdi and outlet shaft at Bhandup of 11.8m diameter , 108m deep inlet shaft at Kapurbawdi.
3. Excavation by drilling and controlled blasting method at tail and TBM removal area at Bhandup and Disposal of muck.
4. Boring of Tunnel from Kapurbawdi to Bhandup with upward gradient 4.5:1000 by TBM
5. Tunnel boring includes communication facilities, safety measures, lightning, ventilation, dewatering, mucking and its disposal
6. Excavation of Tail Tunnel, Assembly Tunnel and Dismantling areas, at the bottom of Shafts, by conventional drilling and controlled blasting method. Length of Tail Tunnel and Assembly Tunnel is listed below:

Table I

Tail tunnel and assembly tunnel locations

Sr.no	Location	Tail tunnel	Assembly tunnel
1	Kapurbawdi	50m	100m
2	Bhandup	10m	20m

7. Interconnection of upper Vaitarna and diversion main of the manifold at Kapurbawdi Shaft.
8. Manifold at Bhandup Shaft for connection to the existing treatment plant, 900 MLD treatment plant under construction and provision for connecting to future Gargai and Pinjal treatment plants.

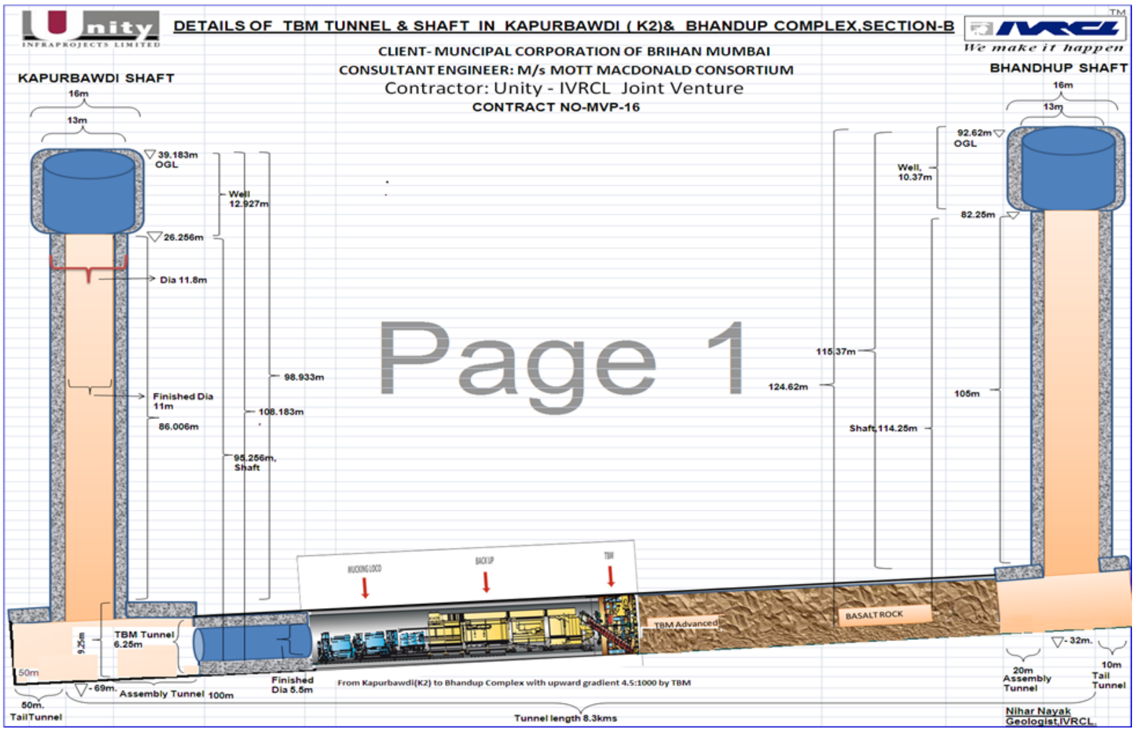

Fig 3. Layout of project showing shaft and tunnel dimensions and location.

IV. SPECIFICATIONS OF TBM:

For the execution of work Robbins hard rock TBM, MB 2011-350 was used. The specifications of which have been mentioned below.

Table II

TBM specifications

Sr. No.	Specification	Results
1	Year of manufacture	2011
2	Machine diameter	246.06”(6250mm)
3	Cutters	
	No. of centre disc cutters 17”	8
	No. of face and edge disc cutters 19”	31
	Maximum recommended individual cutter load	70000lb (311.4Kn)
4	Cutter head power	2310kw
5	Hydraulic system pressure	150kW
6	Motor circuit	11kV
7	Machine conveyor width	36”(914.4mm)
8	TBM weight	424 metric ton

The TBM used is complex in design but relatively simple in concept. At the front of the TBM is a cutter head, diameter of which is equal to diameter of the tunnel required. The cutter head holds the cutter disc (ranging from 14”-20” dia). These are positioned in such a manner that optimal boring of given rock type can be achieved. As the cutter head rotates, hydraulic propel cylinders push the cutters in the rock, causing chips to break away from the tunnel face. Buckets in the rotating cutter head scoop up and deposit the muck onto a belt conveyor inside the main beam. The muck is then transferred to the rear of the machine for removal from the tunnel

The force which thrust the cutter head into the rock face is provided by multiple propel cylinders which are mounted to gripper shoes. The gripper shoes are finally anchored in place by gripper cylinders which push the shoes outwards against tunnelled wall with tremendous force. The gripper shoes provide reaction base for propel cylinders. A TBM boring stroke is completed when propel cylinders are fully extended. At this point the TBM must be regripped, to do so the cuter heads must stop rotating then rear legs are lowered to support machines weight, so that gripper shoes can be retracted from tunnel wall and pulled in ,with the propel cylinder are then retracted which advances the gripper shoes. The gripper cylinder extends the shoes outward once again against the tunnel wall, finally rear legs are retracted and boring can resume.

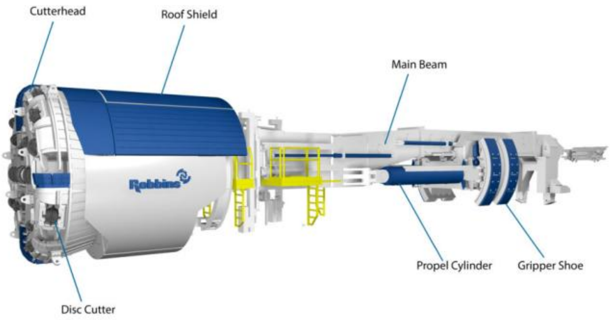

Fig.4 TBM components (source: Robbins TBM)

V. CONCLUSION:

For cities like Mumbai, with rapidly growing population there has been an increase in the water demand. To cater this demand using existing water supply system is impossible. To overcome this challenge, underground water tunnels bored with TBM are considered best for city like Mumbai. These tunnels are designed as earthquake resistant structures and require less maintenance as compared to existing pipeline system. Besides that, water theft and leakages which are a major issue can be overcomed as tunnel is located 60-100mts deep. 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. Besides that 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 make it extremely difficult to lay new water mains of large diameters by open trench method. This makes tunnels bored with TBM the best option of water conveyance, 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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