

# Tunneling for Smart Cities in India

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**Abstract**—This paper will give a general description about the various tunneling methods which will be used in the construction of smart cities or the development of a city into a smart city in India. Techniques such as cut and cover, drill and blast, bored tunneling and new Austrian tunneling method. A summary of environmental merits and demerits associated with these methods are also given. Above tunneling techniques are mostly used to construct small tunnels and find their applications in utility projects to a great extent.

**Index Terms**— Sequential-regular succession without gaps, Tunneling-constructions of passage from obstruction

## I. INTRODUCTION

Development of tunnels has a very important role for the construction of smart cities within India or development any city tunneling is very important. The Dimension and location of the tunnel depends upon its purpose.

The following is a list the major aspects for consideration when constructing a tunnel.

1. Setting out the alignment and clearances.
2. Doing geotechnical survey to find out the types of materials that the tunnel will be passing through.
3. Selection the best construction method.
4. Determine drainage and lining requirements.
5. Selection of appurtenances such as safety provisions, ventilation, lighting, power supply, fire protection.
6. Establish operation and maintenance procedures.

Based on the geotechnical investigation any of the following methods are adopted-

a. **Cut and Cover Tunneling** – As the name indicates the construction of tunnel is done in three different parts excavation, construction and

backfilling. This methods consists several overlapping work. Construction work is carried out from bottom to top so suitable for the places where large area is available The method can accommodate changes in tunnel width and non-uniform shapes and is often adopted in construction of underground stations

b. **Drill and Blast** – This method use explosives for tunneling. On the tunnel surfaces several holes are drilled starting from dummy hole and charged explosive are placed in the holes. Once blasting is carried out, waste rocks and soils are transported out of the tunnel before further blasting. Mostly used in the rocky areas such as hilly regions. Since for explosive the permission from the government is necessary so not used at all the places. A temporary magazine site is often needed for overnight storage of explosives.

c. **Bored Tunneling by Tunnel Boring Machines (TBM)** – This method use a machine known as Tunnel boring machine for construction of long tunnels. Since the TBM consist of cutting blades so evaluation of correct geological conditions is very important. Hard rock can cause significant wear of the TBM rock cutter and may slow down the progress of the tunneling works to the point where TBM becomes inefficient and uneconomical. An effective TMB method requires the selection of appropriate equipment for different rock mass and geological conditions.

d. **New Austrian Tunneling Method (NATM)**- This method is mostly used at the places where there are existences of structure. The tunneling is done by the help of hydraulic breakers. This method has solved almost all the type of problems which we will face in any type of methods such as problems related to permission, explosive, clearance of traffic etc. Another process relates to the ground modifications such as grouting and ground freezing is also common

with this method in order to stabilize the soil for tunneling.

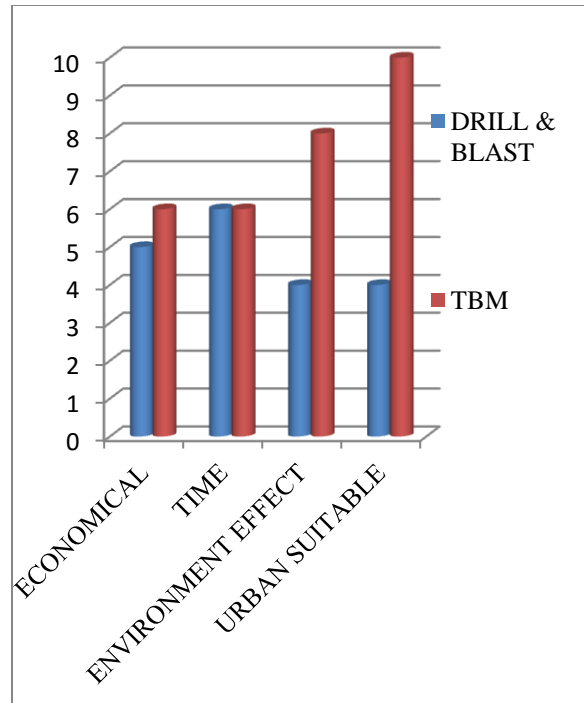
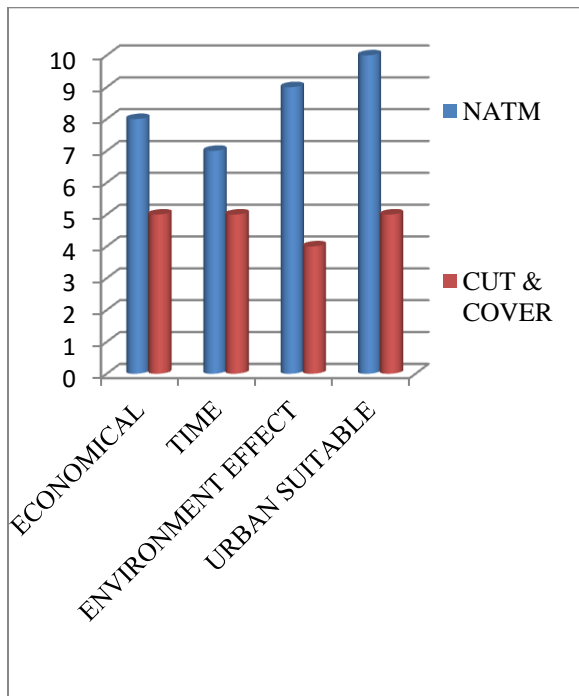
II. COMPARISONS AMONG THE METHODS TO FIND OUT BEST METHOD OF CONSTRUCTION

<b>New Austrian Tunneling Method(NATM)</b>	<b>Cut and Cover Method</b>
1. More efficient in mixed ground	1. More efficient in homogeneous ground
2. Use cast in situ concrete	2. Use both precast and cast in situ concrete
3. Suitable is any structure exist on above ground surface	3. Not suitable is any structure exist on above ground surface
4. Not cause any dust, noise emission problems	4. Cause dust, noise emission and visual impact
5. Less material are generated at construction hence need less handling	5. Large material are generated at construction hence need proper handling
6. Economical for short tunnel	6. Economical for long tunnel
7. Construction steps- <ul style="list-style-type: none"> <li>• Excavation by Hydraulic cutters</li> <li>• Lining the tunnel</li> <li>• Finishing of tunnel</li> </ul>	7. Construction steps- <ul style="list-style-type: none"> <li>• Excavation by excavators</li> <li>• Construction of tunnel</li> <li>• Backfilling of soil</li> </ul>
8. More disturbance to local traffic and associate environment	8. Less disturbance to local traffic and associate environment

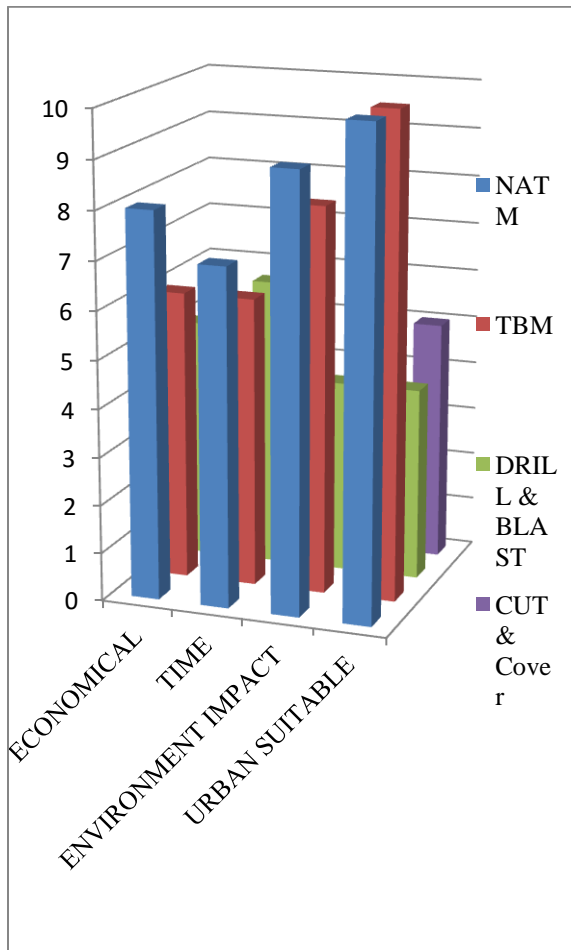
<b>Drill and Blast Method</b>	<b>Tunnel Boring Machine(TBM)</b>
1. Use cast in situ concrete	1. Use precast concrete
2. Suitable for both mixed and homogeneous ground	2. Suitable for homogeneous ground
3. Margin of payline is high	3. Margin of payline is very less
4. Generally result in high but less duration of vibration	4. Generally result in low but long duration of vibration
5. Tunnel surface is excavated by using explosive	5. Tunnel surface is excavated by continuous rubbing of cutting tools on tunnel surface
6. More disturbance to local traffic and associate environment	6. Less disturbance to local traffic and associate environment
7. Economical for short tunnel	7. Economical for long tunnel
8. Any shape is preferred	8. Mostly round shape is preferred
<b>New Austrian Tunneling Method(NATM)</b>	<b>Tunnel Boring Machine(TBM)</b>
1. More efficient in mixed ground	1. More efficient homogeneous ground
2. Use cast in situ concrete	2. Use precast concrete
3. Economical for short tunnel	3. Economical for long tunnel
4. Slow process	4. Fast process
5. Any shape is preferred	5. Mostly round shape is preferred
6. Suitable for rocky surface	6. Not suitable for rocky surface
7. No time is spend on installation of instruments	7. Huge time is spend on installation of instruments

8. Use hydraulic cutter for excavation	8. Use cutting tools to rub on surface for excavations
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III. GRAPHICAL COMPARISONS AMONG THE METHODS BASES ON THE CONSTRUCTION OF A 300METER TUNNEL IN NEW DELHI,INDIA



IV. COMPARISON OF ALL THE METHODS ON A COMMON GRAPH



Note-

The above graph is based on the estimated data of the tunnel constructed at Kalkaji, New Delhi, India. Based on the data collected from geotechnical department about the sub ground condition and after analysis the terms and condition of all the methods of tunneling the best suited method of construction is selected which gives the best benefit. As per the graph the best suited method is NATM.

The selection of methods varies from place to place depends upon the survey, Location and various other permission and as per that graph changes.

V. CONCLUSION

As it is clear from the above comparison NATM is best suited for the construction of tunnel

Following are the constructions steps-

- Profile outline of the NATM is transfer to the ground and this work is done by survey department
- Once the outer profile is transferred to launching tunnel with help of the double boom jumbo machine drilling is started
- Once the drilled is made upto 1meter deep ribs are installed on the circumference of tunnel
- Now the wire mess of 150\*150mm is placed in the circumference of tunnel and placed in position with help of rock bolting
- Latis girder of 2.80 meter length is placed after every 1 meter
- Latis girder on circumference are bolted to each other and anchoring rods are provided same as rock bolting to support latis girder
- Now shortcreting of M15 is done with shortcrete spraying machine

VI. FINISHING OF NATM

- First of all the base is leveled
- Now for water proofing a layer of geo textile is placed and then a layer of PVC is fixed over it by heating rounder at 400 degree
- After water proofing now kerb beam is constructed at corners of tunnel
- With help of H-frame reinforcement is fixed at position and fixed by 300mm drilled anchored rod
- The gantry is placed below it and then the concreting is done(M40)

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