

Pune Underground Metro Project : Challenges and Remedies

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Abstract - The rapid pace of urbanization in metropolitan areas has intensified the need for efficient, reliable, and well-organized transportation systems. Underground metro networks offer an effective and environmentally sustainable means of addressing urban mobility challenges. With increasing population density and limited land availability, the development of underground metro infrastructure has become a crucial component of modern urban planning.

The Pune Metro Project has been conceived as a sustainable urban transport initiative aimed at reducing traffic congestion resulting from the city's rapid growth and expansion. It is designed to provide a fast, safe, and convenient mode of travel while minimizing environmental impact. Ultimately, the Pune Metro is envisioned to form the core framework of the city's public transport system, ensuring greater connectivity and commuter comfort.

In difficult climatic conditions, the development of subterranean space, such as metro lines, requires meticulous planning, design, and the application of cutting-edge building techniques. This study discusses the limitations that arise, such as TBM and ground vibrations caused by construction activities.

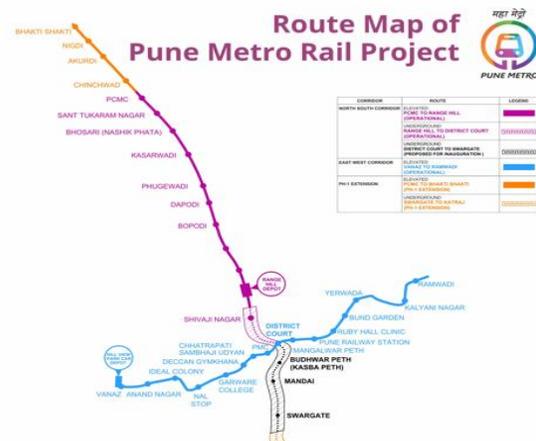
During the construction of the subterranean segment between Range Hill Depot and Swargate Station (an historic heritage structure), heavy soils, water seepage under low rock cover, and tunneling beneath the Mutha River were all addressed. These unfavorable circumstances could have a major impact on the project's budget, timeline, and public perception.

Keywords: TBM, NATM, DRILLING PILING, INSTRUMENTATION, GROUTING, TUNNEL RING SEGMENT, BCS.

I. INTRODUCTION

The Pune Metro Rail Corporation (PMRC) is implementing two principal corridors—Line-1 and Line-2—to strengthen Pune's public transportation

network., extending from PCMC to SWARGATE, comprises an 11.57 km elevated section and a 5.019 km underground corridor. The underground portion of this line has been divided into two major civil packages: UGC-01, spanning from Range Hill Depot to BudhwarPeth Station, and UGC-02, extending from Budhwar Peth to Swargate Station



The execution of both underground packages—UGC-01 and UGC-02—has been awarded to Gulermak–Tata Projects Limited Joint Venture (JV). This alignment traverses densely built-up urban zones and crosses the Mutha River, presenting significant engineering and geological challenges. The confined city environment, coupled with variable subsurface conditions, necessitated the use of advanced tunneling techniques such as Tunnel Boring Machines (TBMs) and strict monitoring of ground settlement and vibration impacts.

The complex nature of this underground alignment makes it a representative case for studying modern urban tunneling methodologies in India, particularly those adapted to congested metropolitan conditions

II. CHALLENGES AND REMEDIES

1. Geological and Geotechnical Challenges

The underground corridor of the Pune Metro passes through diverse geological formations, including basalt, weathered rock, and mixed ground with variable strength and permeability. These conditions posed difficulties in maintaining face stability and controlling water ingress during tunneling operations.

Remedies:

- Use of Earth Pressure Balance (EPB) Tunnel Boring Machines (TBMs) capable of handling mixed ground conditions and maintaining face pressure.
- Continuous geotechnical monitoring using borehole logging, ground-penetrating radar (GPR), and real-time TBM data analysis.
- Grouting and dewatering systems implemented at critical locations to minimize water seepage and maintain tunnel stability.

2. Ground Settlement and Vibration Impacts

Excavation in highly built-up areas, especially near heritage structures and old foundations, created risks of ground settlement and vibration-induced damage.

Remedies:

- Pre-construction building condition surveys and instrumentation (inclinometers, settlement markers, vibration sensors) were installed to monitor ground behavior.
- Controlled TBM advance rate and pressure adjustments to minimize ground movement.
- Application of compensation grouting beneath sensitive zones to control settlement in real time.

3. Crossing of the Mutha River and Water Table Management

The alignment passes beneath the Mutha River, presenting challenges due to high groundwater pressure and risk of water ingress into the tunnel face.

Remedies:

- Adoption of water-tight segmental lining with double gasket systems to prevent leakage.
- Pre-treatment of the tunnel path through chemical grouting to reduce permeability.
- Installation of automated dewatering pumps and waterproofing membranes at shafts and stations near the river.

4. Space Constraints in Dense Urban Areas

The central Pune area, including Shivajinagar, Budhwar Peth, and Mandai, is characterized by narrow roads, congested utilities, and limited working space for launching shafts and station boxes.

Remedies:

- Construction of vertical shafts and launch/retrieval chambers within confined spaces using diaphragm walls and top-down construction techniques.
- Utility relocation and traffic diversion planning in coordination with local authorities.
- Night-time working schedules and noise/dust control measures to minimize disruption to nearby residents.

5. Logistical and Environmental Challenges

Transportation of excavated muck, handling of construction waste, and managing urban pollution levels were additional challenges.

Remedies:

- Deployment of dedicated muck disposal systems with conveyor belts and covered trucks to minimize dust.
- Reuse of excavated material for backfilling and embankment work wherever feasible.
- Regular environmental monitoring for air quality, noise, and vibration to comply with regulatory standards.

6. Safety and Emergency Preparedness

Underground tunneling presents inherent risks such as gas leaks, flooding, and equipment failure.

Remedies:

- Implementation of a comprehensive safety management system, including regular drills and real-time communication between TBM control rooms and surface teams.
- Continuous ventilation and gas detection systems within tunnels.
- Emergency escape shafts and cross passages provided at designated intervals for safe evacuation.

III. SUMMARY

The Pune Underground Metro exemplifies how modern tunneling technology, rigorous monitoring,

and adaptive engineering design can overcome complex urban and geological challenges. The integration of TBM-based tunneling, grouting techniques, and proactive safety management has ensured project continuity while minimizing environmental and structural impacts

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