



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH


IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Special Issue 3, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

Smart cities- Underground Road Tunnel Network in Pune City

Prof.I.M.Jain

Assistant Professor, Dept. of Civil Engineering, Sinhgad Institute of Technology and Science, Narhe, Pune, India

M.R. Khochikar, D.P. Sheth, A.A. Sayyad, T.S. Raut, M.P. Suryawanshi

UG Students, Dept. of Civil Engineering, Sinhgad Institute of Technology and Science, Narhe, Pune, India

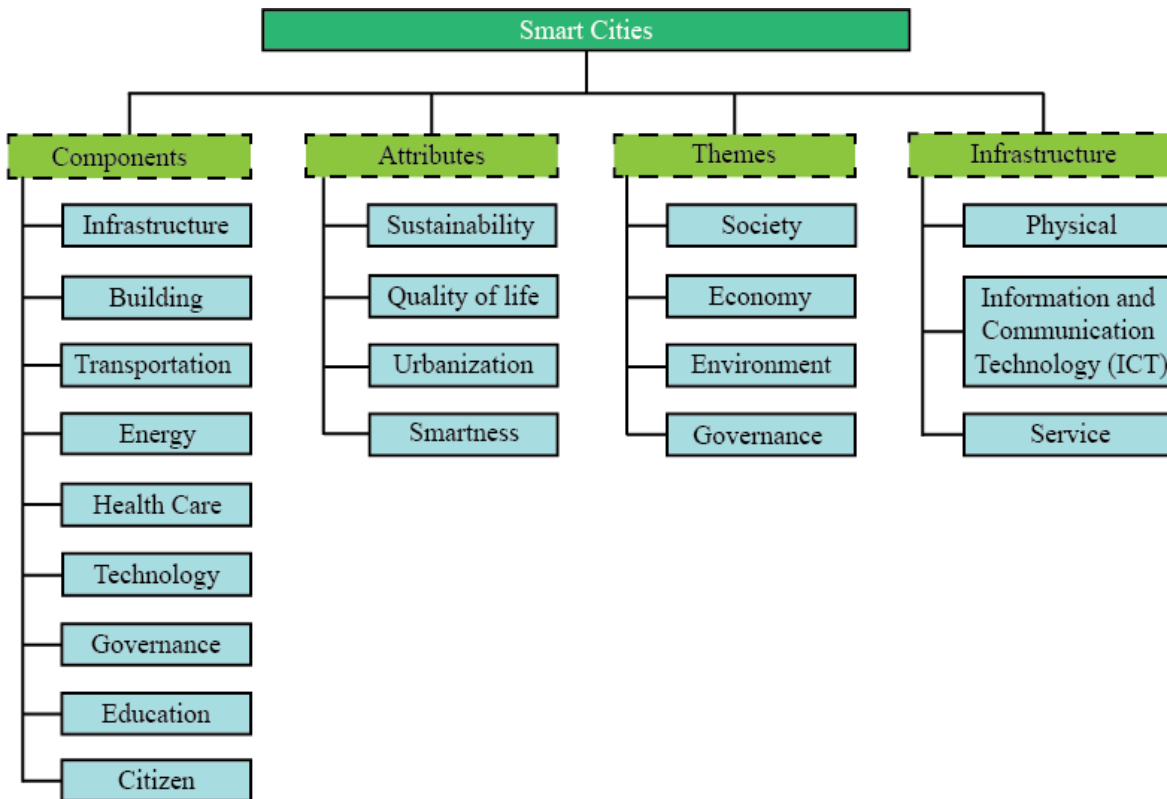
ABSTRACT: The Underground Road Tunnel Network is a transporting engineering project in Pune city that envisions the construction of multiple tunnels across the Pune city to reduce traffic congestion across the various ends of city. This study is carried out to develop alternative roads by underground tunnel network and to increase average travel speed in pune city. This research aims to assess the influence of increase in traffic intensity in Pune city. In this paper we estimated the total length of tunnel network.

I. INTRODUCTION

A smart city is sustainable city that solves urban problems and improves citizens quality of life through the fourth industrial revolution technology and governance between stake-holders. Due to rapid urbanization, smart cities are emerging to solve urban problems from various fields such as transportation, environment, welfare, economy, safety, energy, and the efficient distribution of urban resources.

The smart city is a concept and there is still not a clear and consistent definition of the concept among academia and practitioners. In a simplistic explanation, a smart city is a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital and telecommunication technologies, to improve its operations for the benefit of its inhabitants. A city "connecting the physical infrastructure, the information technology infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city". A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.

There are many components of a smart city and 8 different components have been presented in the figure. The components of a smart cities include the following: smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart technology, smart governance, smart education, and smart citizens. Different smart cities have different levels of these smart components, depending on their focus.



1.1 Transportation Engineering

A good road network is crucial for smart city development because it enhances accessibility, improves mobility, reduces traffic congestion, promotes economic growth, supports sustainable transportation options, and facilitates the implementation of smart infrastructure and technologies like traffic management systems and autonomous vehicles. A robust road network is essential for the development of a smart city, serving as the backbone of its transportation infrastructure. Such a network ensures accessibility and mobility, enabling residents to easily reach their destinations for work, education, and recreation. By reducing traffic congestion through efficient planning and implementation of intelligent traffic management systems, it promotes smoother traffic flow and minimizes travel times. This, in turn, supports economic growth by facilitating the movement of goods and services, optimizing supply chains, and fostering a conducive environment for businesses to thrive. Additionally, a well-designed road network promotes sustainable transportation options such as walking, cycling, and public transit, contributing to reduced carbon emissions and improved air quality. Integration of smart technologies into the road network further enhances its functionality, allowing for real-time monitoring, efficient management of resources, and the implementation of innovative solutions like autonomous vehicles. Ultimately, a good road network not only enhances connectivity and safety but also lays the foundation for a smarter, more sustainable urban environment.

II. HISTORY OF PUNE CITY

Pune, historically known as "PunyaNagari" or the City of Virtue, boasts a rich tapestry of cultural heritage dating back over 2,000 years. Once the seat of the Maratha Empire and later a prominent center of the Peshwas, Pune has evolved from a strategic military outpost to a vibrant cosmopolitan hub renowned for its educational institutions, IT sector, and manufacturing industries.

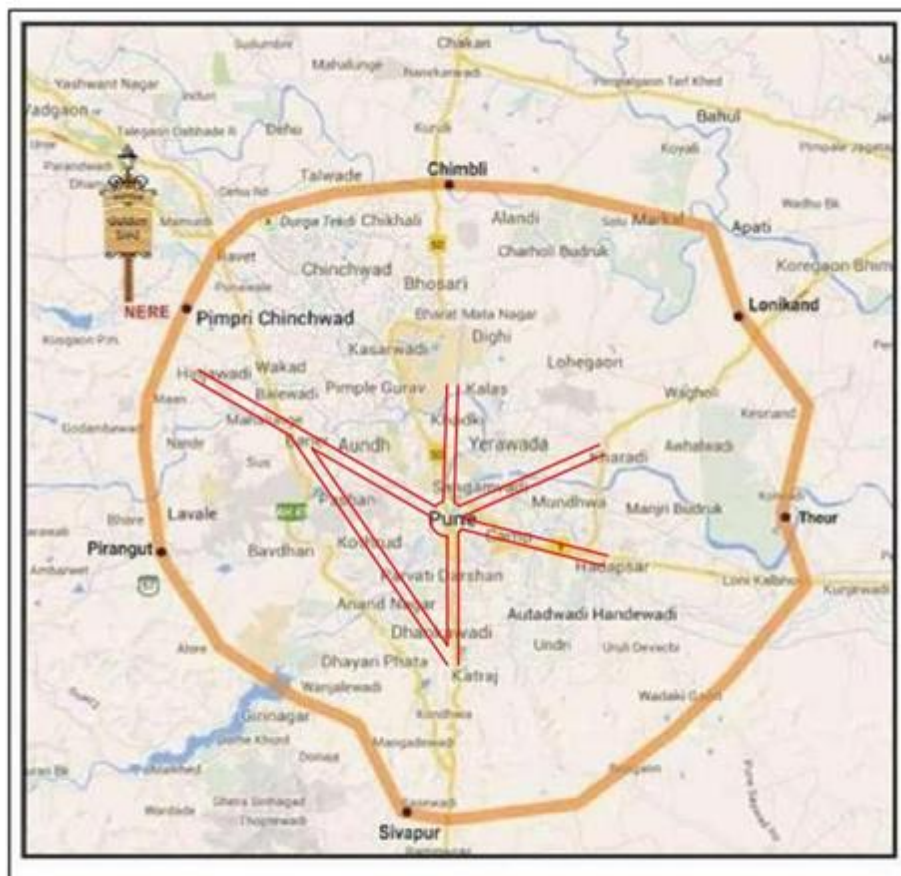
As Pune's population has surged in recent decades, driven by urbanization and industrialization, the city has grappled with the challenges of increasing traffic congestion. The historical layout of Pune, characterized by narrow streets and unplanned development, exacerbates traffic woes. Rapid population growth, coupled with a burgeoning number of vehicles, has placed immense strain on the city's road infrastructure, leading to bottlenecks, gridlocks, and extended travel times.

To address these issues, Pune has undertaken various initiatives to modernize its transportation network. The construction of new roads, bridges, and flyovers aims to alleviate congestion at key junctions and enhance connectivity between different parts of the city. Moreover, the introduction of public transportation systems, such as the Pune Mahanagar Parivahan Mahamandal Limited (PMPML) buses and the Pune Metro Rail project, seeks to provide viable alternatives to private vehicle usage and reduce traffic congestion.

However, managing Pune's traffic remains a multifaceted challenge that requires holistic urban planning, investment in infrastructure, and the adoption of sustainable transportation solutions. As the city continues to grow and evolve, addressing traffic congestion will remain a priority to ensure Pune's livability, economic vitality, and environmental sustainability.

2.1. Need of the Project

Area wise Pune District is the second largest district in the state of Maharashtra (15643 sq. km.). Population wise, it is the most populated district in the State (94,26,959 as per 2011 Census). Pune is at the junction of three major highways, NH-4, NH-50 and NH-9 from which heavy outbound traffic passes through each day, that severely affects the infrastructure and traffic situation in the city. The traffic in and around Pune City has been increasing at high rate due to industrial and other socioeconomic developments in and around Pune City. As a result, roads radiating from the city in all directions are required to be widened to 4 lane/ 6 lanes. Besides, the vehicles that are required to bypass the city are also passing through the city, thereby, creating traffic congestions. Such passing traffic, if diverted through a better road network under the city which will ease the traffic congestion within the city. In absence of such underground road network, the load of external floating traffic is ever increasing on the intra city road network.





2.2. Underground Road Tunnel Network:

Tremendous increase in traffic produces traffic congestion which leads to delay in office or increases travelling time. It also increase stress and health issues, to reduce this problem, it is necessary to plan such a road network which does not disturb daily traffic movement and also reduce travelling time without any congestion.

This underground road network will not only reduce traffic but will also reduce traveling time. Proposed Design routes are

- Katraj- Swargate- Yerawada
- Kharadi-Swargate-Hinjewadi
- Hadapsar-Swargate-Hinjewadi
- To reduce the Chandani chowk congestion a tunnel from katraj will be constructed and will be connected to the Swargate - Hinjewadi Route near Baner.

A underground rotary should be constructed at Swargate.

This underground road network shall be used to travel from one end of the city to other end and their will be no entry or exit in between the tunnel route.

It will be a 4 lane underground tunnel road.

Routes	Distance		Time	
	Before	After	Before	After
Katraj To Yerawada	14 Km	11.68 Km	60 Mins	14 Mins
Kharadi To Hinjewadi	33 Km	26.09 Km	110 Mins	32 Mins
Hadapsar To Hinjewadi	31 Km	26.08 Km	110 Mins	32 Mins
Katraj To Baner	22 Km	17.8 Km	40 Mins	21 Mins
<p><u>Note:-</u> The average Speed of moving vehicle in a Tunnel to calculate time was assumed as 50KMPH.</p>				

III. METHODOLOGY

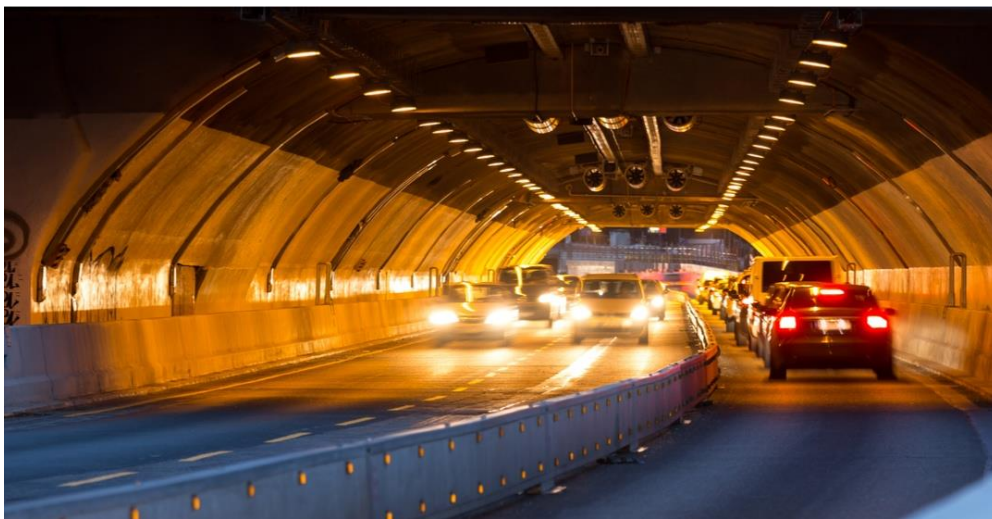
This project will not only reduce the travelling distance but also will drastically reduce the travel time.

This project can reduce a huge traffic conjection in major routes of Pune city.

Since the tunnel passes through the core structures and important parts of the city, it is necessary to construct it with upmost care causing zero damages to the upper structures for which we can use the modernist tunnelling method known as New Austrian Tunnelling Method.

3.1 Parameters.

1. Length = 17m [4-lane road]
2. Diameter =18m
3. Clearance Height = 6m
4. Ventilation = longitudinal and transverse Ventilation
5. Gradient = 3%
6. Emergency Exist = side walk exits at every kilometer which will also be used for maintenance.
7. Drainage = Sump- Pump Drainage system
8. Construction method = Sequential Excavation method / New Austrian Tunnel method
9. Lighting = High power light at entry and exit to avoid black hole effect.
10. Machine to be used for tunneling = tunnel Boring machine(TBM)



3.2. Tunneling method-NATM.

The New Austrian Tunneling Method (NATM) is a widely used technique for the construction of underground tunnels. Originating in Austria in the 1960s, NATM has since been employed in tunneling projects worldwide due to its flexibility, adaptability to different geological conditions, and cost-effectiveness.

NATM involves excavating the tunnel in sequential stages while providing immediate support to the tunnel face using a combination of shotcrete (sprayed concrete), rock bolts, and steel ribs or lattice girders. This initial support system stabilizes the tunnel walls and prevents collapses during excavation. As the tunnel progresses, additional layers of shotcrete and reinforcement are applied to create a durable lining.

One of the key advantages of NATM is its ability to adapt to varying geological conditions encountered during tunneling. By continuously monitoring ground conditions and adjusting the tunnel design and support system accordingly, NATM allows for efficient excavation in challenging environments such as rock, soil, or mixed ground.

NATM also offers flexibility in tunnel design, allowing engineers to optimize the cross-section and alignment of the tunnel to meet specific project requirements. This flexibility can help minimize construction costs and environmental impact while maximizing the tunnel's functionality and longevity.

Overall, NATM has proven to be a versatile and effective method for tunnel construction, offering advantages in terms of adaptability, cost-effectiveness, and structural integrity.

3.3 Tunnel Boring Method(TBM).

A Tunnel Boring Machine (TBM) is a specialized piece of construction equipment used to excavate tunnels with a circular cross-section through various soil and rock types. TBMs are designed to bore through hard rock, soft ground, or a combination of both, depending on the specific geology of the tunnel alignment.

TBMs consist of a rotating cutting head equipped with disc cutters or cutting tools that break apart the soil or rock face. Behind the cutting head, there is a system for removing excavated material, typically through a conveyor belt or a system of buckets. Additionally, TBMs are equipped with a series of support systems, including tunnel lining segments or precast concrete rings, which are installed behind the TBM to stabilize the tunnel walls and prevent collapses.

TBMs come in various sizes and configurations, depending on the diameter and length of the tunnel to be excavated, as well as the geological conditions. Some TBMs are designed specifically for soft ground conditions, such as clay, sand, or gravel, while others are optimized for hard rock tunneling.

The use of TBMs offers several advantages over traditional tunneling methods, including faster excavation rates, improved safety for workers, reduced disturbance to the surrounding environment, and greater accuracy in tunnel alignment. However, TBMs are also expensive to procure and operate, and their use may be limited by factors such as tunnel length, geology, and project budget.

Overall, Tunnel Boring Machines play a crucial role in modern tunnel construction projects, enabling the efficient and cost-effective excavation of tunnels for transportation, utilities, and other infrastructure needs.

3.4 Ventilation.

In tunnel ventilation, longitudinal ventilation involves the airflow moving along the length of the tunnel, typically from one end to the other. This method helps to control air quality by removing pollutants and managing temperature. It's often achieved through the use of ventilation shafts or fans positioned along the tunnel's length.

Transverse ventilation, on the other hand, involves airflow across the width of the tunnel. This method is particularly useful in longer tunnels or areas where longitudinal ventilation alone may not be sufficient to maintain air quality and control temperature. Transverse ventilation systems often utilize jet fans or ducts positioned at intervals along the tunnel's cross-section to ensure adequate airflow and distribution of fresh air.

3.5 Drainage system.

In tunnels, a sump pump drainage system is commonly used to manage water accumulation. Sump pumps are installed in designated sump pits strategically placed along the tunnel's length. These pumps automatically activate when water levels rise above a certain threshold, pumping the water out of the tunnel and into a drainage system or a nearby outlet. The sump pump drainage system helps to prevent waterlogging, which can compromise the structural integrity of the tunnel and pose safety risks. It's particularly important in underground transportation tunnels, where water infiltration can lead to operational disruptions and safety hazards for commuters. Regular maintenance and monitoring of sump pumps are essential to ensure their effectiveness in keeping tunnels dry and safe.

3.6 Lighting.

To prevent the black hole effect in tunnels, where drivers experience a sudden transition from daylight to darkness, proper lighting design is crucial. Here are some key strategies:

- Entrance and Exit Transition Zones: Gradually transition lighting levels at tunnel entrances and exits to mimic natural light changes. This helps drivers' eyes adjust smoothly as they enter or exit the tunnel.
- Uniform Illumination: Ensure uniform lighting levels throughout the tunnel to minimize contrast between bright and dark areas. This helps maintain consistent visibility for drivers.
- Lighting Color Temperature: Use lighting with a color temperature similar to daylight (around 5000-6500 Kelvin) to improve visibility and reduce eye strain.
- Continuous Lighting: Avoid gaps or dark spots between light fixtures by providing continuous lighting coverage along the entire length of the tunnel.
- Emergency Lighting: Install emergency lighting systems that automatically activate during power outages or other emergencies to ensure continued visibility and safety for drivers.

By implementing these lighting strategies, the black hole effect can be mitigated, enhancing safety and comfort for tunnel users.

IV. SAFETY FEATURES

- Emergency exits at regular intervals.
- Adequate lighting for visibility.
- Ventilation systems to prevent buildup of harmful gases.
- Fire suppression systems and fire-resistant materials.
- CCTV cameras for monitoring.
- Emergency communication systems (phones, intercoms).
- Emergency response stations.
- Clear signage for directions and emergency procedures.
- Regular maintenance checks for structural integrity.



- Crash barriers or guardrails where needed.

V. ESTIMATION

5.1 Cost And Financial Aspect

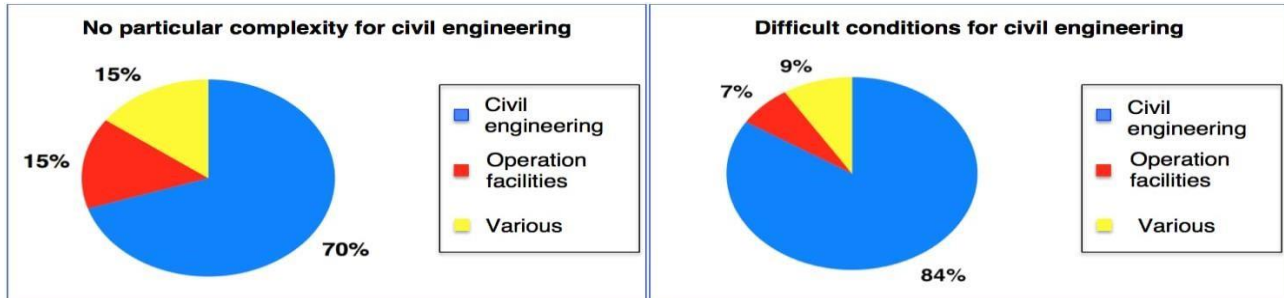
The construction costs of tunnels are very variable and it is impossible to give representative ratios of costs per kilometre, because these ratios may vary in important proportions (average of 1 to 5) according in particular to

- The geological conditions
- Difficulties concerning the access roads and the tunnel portals
- The length of the tunnel
- The traffic volume which is a determining factor for the dimensioning of the number of lanes, as well as for the ventilation facilities
- Chosen construction methods as found to be the most technical and economically viable.

5.2 Breakdown Of The Construction Costs

The construction cost of a tunnel may be broken down into three types of cost:

- The cost of the civil engineering structures
- The cost of the operation facilities, including the supervision centre and the energy supply from public networks
- Various costs including in particular: owner’s costs for the development of the project – project management – design and site supervision – survey and ground investigations - environmental studies and mitigation measures – land acquisitions - various procedures - etc.



VI. CONCLUSION

In this paper, a detailed study is shown on how providing a tunnel can help us in reducing the traffic congestion in major parts of the Pune city. It also shows the reduction of average travel time required to reach the destination using underground road tunnel, This helps in not only saving the Fuel but can also help in reducing the Pollution.

REFERENCES

1. Joshi Sujata, et al. “Developing Smart Cities: An Integrated Framework”, International Conference on Advances on Computing & Communications ICACC, Procedia Computer Science, vol. 93, Elsevier, 2016. pp 902-909
2. Evelin Priscila Trindade et al., “Sustainable development of smart cities: a systematic review of the literature”, Springer journal of open innovation, technology, market and complexity, volume 3, issue 11, 2017, PP 1-14
3. Tarana Singh et al. “Decade Review on smart cities: Challenges and opportunities, Multidisciplinary, Rapid Review, IEEE Access, volume no 10, issue 7, 2022, PP 68319-68360.
4. Zijia Wang “Research on Smart City Environment Design and Planning Based on Internet of Things, Hindawi Journal of Sensors, Volume 2022, PP 1-9
5. Saraju P.Mohanty, et al., “everything you wanted to know about smart cities” department of Computer Science & Engineering, University of North Texas, Denton, TX 76203.
6. N.Rajesh Goud, “Construction of Atal Tunnel” department of Civil Engineering, Jawaharlal Nehru Technological University, Hyderabad, IJIERT, Volume 8, Issue 8, Aug-2021.



|| Volume 13, Special Issue 3, May 2024 ||

| DOI:10.15680/IJIRSET.2024.1305911 |

7. Anuj Pawar, et al., “Design of Coastal Road in Mumbai City”, Department of Civil Engineering, Sardar patel College of Engineering, Andheri(W), Mumbai, India, IJER, Volume 5, Issue Sp.1, Jan 2016, PP: 80-84.
8. Md. Alqamar Azad, et al., “Application of NATM methodology for the Excavation of rail Tunnel in Difficult Geological Conditions”, A case Study from Garhwal Himalaya, Uttarakhand, Journal of geological Society of India 98, 1553-1559, 2022.
10. Dr.P.D. Sabale, et al., “Tunnel Construction- A case Study of Pune Metro Maha-Metro, IJRES, Volume 10, Issue 7, July 2022, PP:590-593.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details