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# Overcoming Challenges of Utility Management in a Growing Megacity: Lessons from Mumbai

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A B S T R A C T

Mumbai (in India) is experiencing a rapid increase in population, leading to a high demand for modern utilities such as 5G, gas lines, and metro trains. This surge in utility demand has resulted in a large number of utility cables and lines, leading to what is known as the "traffic of utility." Thirty-six different utility agencies are responsible for laying new utilities, repairing faults, or making street connections, which often cause inconvenience to the public. As the population and standards of living increase, citizens expect timely and high-quality services from municipal corporations and other providers. Pipes or wires are typically used to provide services such as water supply, drainage, power supply, telecommunication, and gas lines, but many of the utilities in Mumbai are over a century old and are difficult to maintain or replace. This presents problems because it is challenging to locate subsurface utilities, causing delays, additional work orders, and property damage. Mumbai needs a new system to support the rise of utilities, and this article discusses the history of Mumbai, which dates back to the formation of seven islands that were part of the kingdom of Ashoka. The article also covers Navi Mumbai, which was established in 1965 to alleviate congestion on the mainland of Mumbai and shift industrial and housing demands to the peripheries.

Keywords: Mumbai, Navi Mumbai, Utility Management etc.

## 1. INTRODUCTION

Mumbai, the financial and economic hub of India, has a rapidly growing population of around 12.5 million, and this increasing populace has generated an ever-increasing demand for advanced technology. The demand for technology has evolved over the years, from 2G to 3G, then 3G to 4G, and now, from 4G to 5G. This shift in demand has prompted a corresponding change in the utility cables, with the requirement for extra lines to cater to the increasing population. This change in demands has led to what can be termed as the "traffic of utility" in Mumbai. There are nearly 36 different utility agencies that lay their utility lines, pipes, and cables beneath the municipal roads in MCGM. These agencies dig up roads for laying new utilities, repairing faults, street connections, etc. However, this perpetual digging causes damage to the footpaths and carriageways, causing inconvenience to the public. Mumbai has the highest number of utility agencies digging up roads for repairing or maintaining lines of electricity, telephone, internet connections, and cooking gas supply in any Indian city.

Pipelines and cables for almost all utilities in Mumbai are installed underground, typically below the level of the road, including carriageways and footpaths. The need for services has increased due to population growth and rising standards of living. Citizens have also come to expect timely, high-quality service from municipal corporations and other service providers. However, the increase in traffic below the road's surface has made it more challenging to lay new cables or pipelines and increased the frequency of faults that call for excavation to be carried out. The subsurface utilities cannot be visually inspected, making it difficult to find them underground. This difficulty causes delays, additional work orders, change orders, construction claims, contingency bids, interruption of service, property damage, and so on. Certain utilities in Mumbai are over a century old, and consumers are often unaware of their existence, leading to the deterioration of their services as they age. The ambiguity around the locations of subsurface utilities is problematic. Therefore, a new system needs to be established to support the rise of utilities in Mumbai. This study aims to understand and address the challenges faced

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by utility agencies in Mumbai by proposing an innovative solution to streamline the process of laying new utilities and repairing existing ones while minimizing the inconvenience caused to the public. The proposed system will ensure that the services provided by utility agencies are timely, efficient, and of high quality.

This study will leverage detailed information to maintain a comprehensive database of all subsurface utilities in Mumbai. This database will provide accurate information about the location, type, and age of these utilities, making it easier for utility agencies to access and repair them. The database will be built by integrating satellite imagery, aerial photography, and other geospatial data sources. The proposed system will also use the latest techniques in artificial intelligence and machine learning to predict and prevent utility failures, thereby minimizing the need for frequent excavation and repair work. The study will significantly reduce the time and cost required to lay new utilities and repair existing ones. It will also minimize the inconvenience caused to the public by reducing the need for excavation work. The proposed system will improve the overall quality of the services provided by utility agencies and enhance the safety and reliability of subsurface utilities in Mumbai. The study will be a game-changer in the field of utility management in Mumbai. It will provide an innovative and efficient solution to the challenges faced by utility agencies, paving the way for a more sustainable and resilient future for the city.

### *1.1. History of Mumbai*

Mumbai is a fascinating city to study. The history of this city is intertwined with its infrastructure, and its engineering feats and architectural marvels have played a significant role in its growth and development. The seven islands that make up modern-day Mumbai posed unique challenges to engineers and builders throughout history. The islands' varied topography and the surrounding sea made construction difficult, and the need for robust infrastructure was paramount. As a result, Mumbai's engineering marvels are many, from its vast network of bridges and tunnels to its towering skyscrapers.

In the 19th century, Mumbai underwent massive reconstruction, and its economy experienced a boom during the American Civil War. This era of growth and transformation was marked by significant engineering feats and architectural marvels. The construction of the Crawford Market, the Bombay High Court, and the Victoria Terminus (now Chhatrapati Shivaji Terminus) are just a few examples of the city's impressive architecture from this period. Mumbai has also been witnessed to significant upheavals throughout its modern history. The city suffered heavy damage during World War II, and the Hindu-Muslim riots of 1992-1993 left a lasting impact on the city's infrastructure. These challenges have forced civil engineers to continuously innovate and adapt, leading to the development of new techniques and materials.

Despite these challenges, Mumbai continues to evolve and grow. Its infrastructure is among the most advanced in the country, and its architecture is a testament to the ingenuity and determination of its people. Civil engineers continue to play a critical role in shaping the city's future, as they work to address the challenges of population growth, climate change, and urbanization. In addition, Mumbai is a city with a rich history and a vibrant future, and its engineering feats and architectural marvels are a testament to the skill and dedication of its civil engineers. From the seven islands to the modern metropolis, it is today, Mumbai's infrastructure has played a critical role in its growth and development. As a civil engineer, studying Mumbai is a fascinating opportunity to explore the interplay between history, infrastructure, and urban planning, and to witness firsthand the power of engineering to shape the world around us.

### *1.2. A planned city is imagined: Navi Mumbai*

The development of Navi Mumbai provides valuable insights into urban planning and infrastructure design. The inception of this city in 1965 was based on the recommendations of the Barve report and the Bombay Metropolitan Regional Planning Board's Regional Plan. These reports identified the need for a counter-magnet to Mumbai, one that would decongest the mainland and shift the burden of industrial and housing demands to the peripheries.

The primary goal of the Navi Mumbai project was to alleviate the overcrowding and congestion that plagued Mumbai while providing affordable housing for economically weaker sections and low-income groups. The city's design focused on providing adequate infrastructure, such as roads, water supply, sewage systems, and other amenities, to ensure a high standard of living for its residents. One of the key engineering feats of Navi Mumbai was the development of its transportation infrastructure. The city's road network was designed to be efficient and convenient, with a focus on reducing travel time for commuters. The construction of the Mumbai-Pune Expressway and the Vashi Bridge were among the most significant engineering accomplishments in this regard.

Another critical aspect of Navi Mumbai's development was the provision of social infrastructure such as schools, hospitals, and community centres. These facilities were designed to meet the needs of the residents and promote social cohesion. The Navi Mumbai project also provided an opportunity to address the issue of slum clearance in Mumbai. By shifting the focus of development to the peripheries, the project made it easier to clear slums and provide adequate housing for the economically weaker sections of society.

Moreover, Navi Mumbai's development represents a significant engineering and urban planning achievement. Its design and infrastructure were carefully planned to address the challenges faced by Mumbai while providing a high standard of living for its residents. As a civil engineer, studying the development of Navi Mumbai provides valuable insights into the complex interplay between urban planning, infrastructure design, and social needs.

**Nomenclature**

DDMA- District Disaster Management Authority
DM-Disaster Management
FSI-Frequency Severity Index
GH--Gujarat State
MHA-Ministry of Health Affairs
MH-Maharashtra State
NPDM-National Policy on Disaster Management
NEC- National Executive Committee
NDMA-National Disaster Management Authority
SDMA- State Disaster Management Authority

## 2. Overview of Utility

Mumbai, one of the busiest cities in India, faces the daunting task of managing its road infrastructure, with 36 different utility agencies digging up roads for maintenance or repair purposes. These agencies include those responsible for electricity, telephone, internet connections, and cooking gas supply. While the agencies dig up roads to lay their cables or for repairs, they often leave the dug-up areas unattended or do a shoddy job when it comes to filling them up. This creates a bumpy surface, making it difficult for commuters and pedestrians to navigate the city. To solve this issue, the BMC has come up with a plan to implement proper ducts for underground utilities that have entry points at regular intervals. This will help shift all the utilities to the ducts and improve their maintenance, resulting in smoother roads. The BMC has allocated funds to this project in its budget and plans to take up the work soon. The project is a long-pending demand and requires thorough scrutiny before implementation. A proper presentation must be given to the standing committee to ensure transparency and accountability. The project is crucial for Mumbai's transportation infrastructure, and the BMC must ensure that the project's execution meets the necessary standards.

The BMC is responsible for maintaining approximately 2000km of the city's roads, and it takes up repair works every year. In its budget this year, the civic body has increased its allocation for road works by 25%, with a provision of ₹ 1,520 crore for more than 300km of road works. This shows the BMC's commitment to improving the city's infrastructure and providing a better commuting experience to its residents. In addition to the road works, the BMC must also ensure proper coordination among the different agencies responsible for the road infrastructure. It is common to see two different agencies working on roads and adjacent footpaths at different times, leading to uneven construction. The BMC must ensure that such coordination issues are addressed to provide a seamless commuting experience for the people of Mumbai. Moreover, the implementation of proper ducts for underground utilities is a crucial project for Mumbai's infrastructure, and the BMC must ensure that it is executed efficiently and effectively. The BMC must also take steps to ensure proper coordination among the different agencies responsible for the road infrastructure to provide a better commuting experience for the people of Mumbai.

From a technical standpoint, the issue of frequent digging up of roads in Mumbai for the maintenance of utility lines is a major concern. The presence of at least 40 types of underground utilities under the roads, including water pipelines, stormwater drains, electricity cables, telecommunication lines, gas pipelines, sewerage lines, and internet cables, makes it necessary for various utility agencies to dig up roads for laying new connections or for maintenance and repairs. However, the lack of proper coordination among these agencies often leads to shoddy work, leaving the roads in a state of disrepair.

In 2016, a high court-appointed statutory technical advisory committee recommended that the Brihanmumbai Municipal Corporation (BMC) implement the Duct Policy to prevent road damage caused by frequent digging. The implementation of roadside ducts is expected to prevent the need for frequent digging of roads for maintenance work. Such ducts are used in many western countries and are known to provide easy access to underground utilities for maintenance and repair works.

According to BMC records, nearly 400 km of roads are dug up every year for laying underground utilities, and this has a significant impact on the quality of roads. The regular trenching by various utility agencies affects the road quality, and the BMC has been asking these agencies to coordinate with them before the road repair works start. However, many times the agencies ask for permission to excavate after the road repair work is completed, leading to uneven construction and further degradation of the road quality.

To address this issue, the BMC has proposed the implementation of ducts for underground utilities, which will be a long-term solution to the problem of frequent digging up of roads. The BMC has increased its allocation for road works by 25% this year, with a provision of ₹ 1,520 crore for more than 300km of road works. The proposed implementation of ducts for underground utilities will not only prevent the frequent digging of roads but will also help in maintaining the road quality and ensuring safe and smooth transportation for the citizens of Mumbai.

The BMC official stated that the civic body had installed ducts on 11 roads in 2013 to manage the underground utility lines, but they were not utilized by the agencies due to various technical difficulties. In response, the BMC developed a revised policy for duct installation in 2018. However, civic activist Sanjay Gurav expressed skepticism about the implementation of the policy, noting that it has been discussed in theory but has yet to be implemented on the ground. It is imperative that the BMC enforces the policy rigorously to ensure that the ducts are utilized to the fullest extent possible, thereby minimizing the damage caused to the city's roads and preventing unnecessary disruptions to traffic.

### *2.1. Utilities in Mumbai*

Mumbai, a bustling metropolis, has a vast road network covering approximately 1940 km. Out of this, around 40% of the roads are made up of cement concrete, while the rest are bituminous and paver block roads. The design and construction of these roads are carried out based on the recommendations of the Standing Technical Advisory Committee (STAC). To ensure the durability and strength of these roads, various tests and traffic surveys are conducted beforehand.

In Mumbai, there are approximately 36 different utility agencies responsible for laying their respective utility lines, pipes, and cables under municipal roads. The constant excavation of these roads for laying new utilities, repairing faults, or establishing street connections can cause significant damage to the footpaths and carriageways, leading to inconvenience for the public.

To address this perpetual trenching problem, the Municipal Corporation of Greater Mumbai (MCGM) has decided to introduce dedicated utility ducts along the municipal roads. However, the planning and designing of these utility ducts will require a coordinated effort between the utility agencies and the MCGM.

To facilitate this coordination and ensure that the underground utility ducts are designed and constructed effectively, the MCGM has planned to appoint consultants for the task. These consultants will work in close collaboration with the utility agencies and the MCGM to plan and design the underground utility ducts. This initiative is aimed at providing a complete engineering solution for the perpetual trenching problem and to ensure the durability and strength of Mumbai's road infrastructure.

The constant changes to underground utilities and the subsequent road work have made managing traffic flow in Mumbai difficult. This has resulted in various issues for Mumbai peoples, including road congestion, potholes, corruption, and the presence of illegal utilities. To address these problems, it may be helpful to classify utilities into categories such as discarded, legal, illegal, and new. However, identifying and managing these categories in a crowded city like Mumbai can be challenging.

To properly classify utilities, a comprehensive system of record keeping and tracking must be implemented. This system should include information on the location of each utility, the type of utility, its age, and its legal status. This information can be collected through a combination of surveys, inspections, and audits. By doing so, the city can track the status of each utility and take appropriate action to remove or replace any illegal or outdated utilities.

To further streamline this process, modern technologies like Geographic Information Systems (GIS) and Global Positioning Systems (GPS) can be used to accurately map and locate utilities. These technologies can provide real-time data on the location and status of each utility, enabling authorities to better manage their maintenance and replacement.

Overall, while classifying utilities may help in better managing traffic and road conditions, it is crucial to implement a comprehensive system of record keeping and tracking, coupled with modern technologies, to effectively manage and maintain the utilities in a crowded city like Mumbai.

### *2.2. Management of utility traffic*

The Municipal Corporation of Greater Mumbai (MCGM) has been facing difficulty managing the traffic of utilities due to repeated digging of roads and redoing road work. The problem is compounded by the lack of coordination between the different utility agencies that lay their pipes, cables, and lines under municipal roads, causing inconvenience to the public. To address this issue, MCGM has decided to lay dedicated utility ducts along municipal roads to ensure that the utility agencies have a designated space to lay their pipes and cables. However, this task requires a coordinated effort between the utility agencies and MCGM, which is why MCGM has invited consultants to plan and design the underground utility ducts.

The consultants are required to carry out various tasks, including preparing an inventory, surveying in detail, coordinating with various external utility agencies, mapping all utility lines/networks accurately, carrying out various tests, studying the traffic, planning, and preparing a comprehensive design for a trench-free pavement with utility ducts, cross ducts, connections to the abutting properties, and preparing estimates/BOQ & drawings for the utility ducts of MCGM roads. However, the laying of utility ducts in a crowded city like Mumbai, which has a population density of 188,340 per km, is a challenging task. One of the main reasons for the delay in the implementation of the project is the lack of proper organization to oversee the three consultants appointed for the project. Additionally, there are no proper ways to distribute arterial roads to the consultants, and no proper records are available of the existing utilities, making it difficult to identify and classify them.

Another challenge is the design of coordination loops, where arterial roads are given to different consultants, resulting in different shapes and arrangements of the utility ducts. This makes it challenging to lay the utilities in a coordinated and efficient manner. The location of utility ducts is another issue, with different consultants proposing different locations, including the centre, left side, or right side of the roads, making it difficult to coordinate and correlate them. Overall, the project to lay utility ducts in Mumbai is a complex and challenging task that requires coordinated efforts between multiple agencies and consultants. Despite the efforts made so far, several technical issues and organizational challenges have delayed the implementation of the project.

## 3. Steps of Utility Traffic Management

In order to effectively manage the traffic of utilities in Mumbai, there are several technical and organizational factors that need to be taken into consideration.

Firstly, there needs to be a dedicated organization or planning body that can oversee the work of the various consultants involved in the planning and designing of underground utility ducts. This organization should be comprised of experts with a deep understanding of Mumbai's geography, and they should be able to provide guidance and support to the consultants as needed.

Secondly, the planning of work needs to be detailed and well thought-out to avoid delays or unexpected issues during the practical working phase. This planning should take into account interdepartmental future work or vision to ensure that the utility ducts are designed to meet future requirements.

Thirdly, the accuracy of ground penetration radar (GPR) survey and trial pit records is critical for the design of utility ducts. These records need to be properly matched and aligned to avoid any conflicts that could impact the design.

Fourthly, the design of the utility ducts must be practical and take into account the unique challenges presented by Mumbai's congested and densely populated urban environment. This requires a design that can effectively navigate land constraints and conjugation zones.

In conclusion, effective management of the traffic of utilities in Mumbai requires a combination of technical expertise and organizational planning. By establishing a dedicated planning body, detailed planning of work, accurate GPR survey and trial pit records, and practical design, it may be possible to reduce the repetitive digging of roads and better manage the utilities in this crowded city.

### *3.1. Ground penetrating radar (GPR)*

Ground penetrating radar (GPR) is a geophysical survey method and the main component of utility detection and mapping survey.Fig. 1 depicts the schematics of the GPR. Some of the features of GPR are as follows:

- an accurate, fast and high-resolution geophysical technique for subsurface investigation.
- non-invasive, non-destructive and completely safe.
- the only non-intrusive method capable of accurately locating non-metallic subsurface features and utilities (e.g., clay, concrete, fibreglass, PVC conduits or fibre-optic cables).
- a geophysical surveying technique based on transmitting pulsed electromagnetic (EM) energy into the subsurface and measuring the strength of the reflected energy.
- successful where a sufficient contrast in material properties (dielectric permittivity) between a buried target and its surroundings exists.
- used by Scan-tech to detect and map buried pipes, cables, structural reinforcement, voids, disturbed ground, material degradation, subsurface layers and buried objects.
- acquired using transmitting and receiving antennae which can be mounted on a cart, skid plate or vehicle, or can be hand-held.
- a technique which requires qualified and experienced personnel to acquire high-quality survey data and geophysical expertise to process and interpret the results.

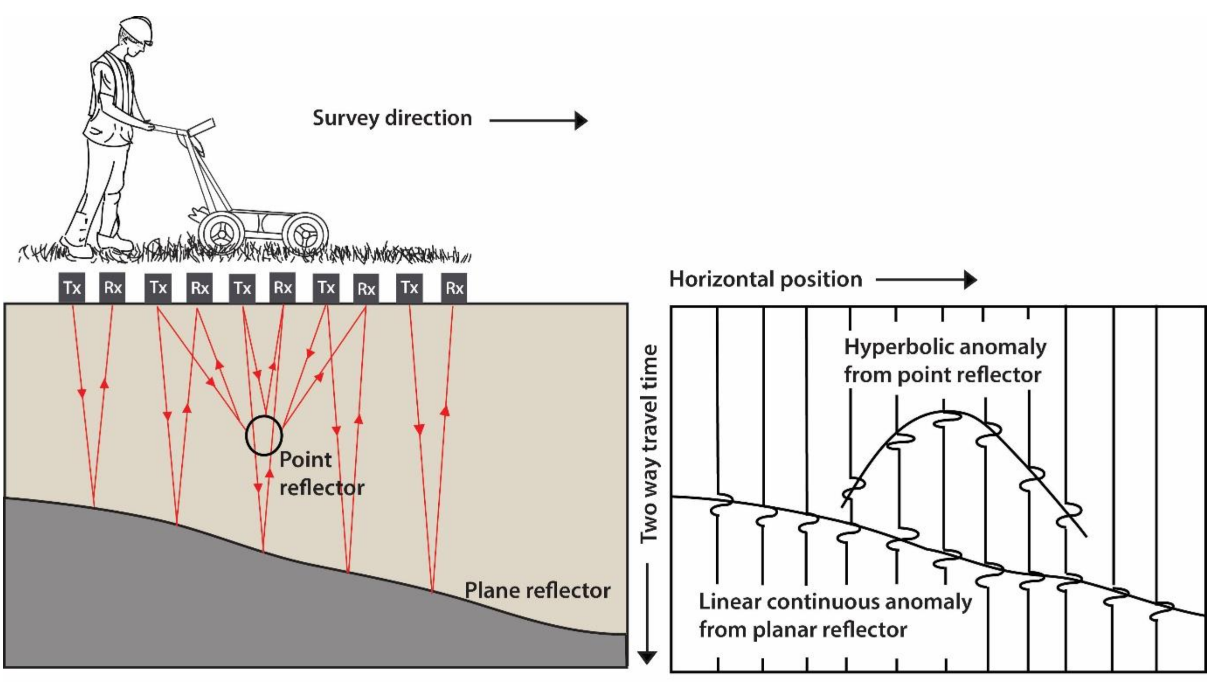


**Fig. 1 - GPR Survey for tracking utility.**

## 4. Conclusion

This study sheds light on the importance of managing utilities effectively in one of the busiest and most popular city Mumbai and can be applied to other metropolitan cities as well. Mumbai has a long and rich history, and as the city has grown, the demand for various utilities has increased. The study provides an overview of the different types of utilities in Mumbai. The analysis of each utility system and its management highlights the challenges faced by the city authorities in providing reliable and efficient services to the citizens. Moreover, the study points out the need for an integrated approach to utility management to address the problems of multiple agencies operating in silos, lack of coordination, and overlapping infrastructure. The study also emphasizes the role of utility trafficking in managing the movement of utilities on Mumbai roads. With the city's limited road space and increasing traffic congestion, the management of utility traffic has become crucial for ensuring smooth traffic flow and reducing the risk of accidents. The study presents a comprehensive overview of the steps involved in utility traffic management, including planning, scheduling, execution, and monitoring. The analysis also highlights the challenges faced by utility traffic management, including the need for adequate training, technology, and equipment. Overall, the study underscores the need for a holistic approach to utility management and traffic management in Mumbai. The city authorities must focus on improving coordination and collaboration among various agencies responsible for utility management. The use of technology, such as smart grids and sensor networks, can help improve the efficiency of utility management and traffic management. The study also recommends the adoption of best practices from other cities around the world to enhance the quality of life for Mumbai's citizens. In conclusion, the study provides a valuable contribution to the field of utility traffic management. The study can be used by policymakers, urban planners, and utility service providers to improve the delivery of essential services to the citizens of Mumbai. With the right approach, Mumbai can overcome the challenges of utility management and traffic management and become a model for other cities in India and around the world.

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