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Study of Trenchless Technology

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ABSTRACT

Trenchless technology consists of a variety of methods, materials, and equipment for inspection, stabilization, rehabilitation, and replacement of existing culverts and installation of new culverts with a minimum of excavation from the ground surface. Some of the methods were available in the early 1900's and with the addition of new techniques are coming into much more widespread use because of their inherent advantages. Trenchless methods minimize damage to the highway, cause little or no disruption to traffic, have less impact on the environment, and occasionally avoid or minimize the handling and disposal of contaminated soils.
Keywords : Introduction, Sections of Trenchless Technology, Subsurface Investigation, New Installations, Rehabilitation, Replacement, Analyzing Indian Trenchless, Advantages, Disadvantages, Technique Applicability, Conclusion, Case Study, References.

I. INTRODUCTION

- A set of techniques for the remote installation, rehabilitation and repair of utilities, pipelines and small tunnels – executed without excavating continuous trenches.
- Depending on the specific situation trenchless methods can be cost-effective alternatives to the more conventional open excavation. The cost is insensitive to depth of cover meaning that work under high fills will be more economical using trenchless technology. Many times the cost is not the main concern; factors such as safety inconvenience of the motoring public and environmental impacts outweigh the initial costs.
- ODOT'S (Oregon Department of Transportation) main application of this technology is in the rehabilitation, replacement, and installation of culverts and storm sewer lines in areas where open excavation is either more costly, not as environmentally friendly, or creates inconvenience for the motoring public.
- The trenchless technology process starts with the identification of a problem. There is a drainage structure that requires some sort of fix. It may need stabilization, rehabilitation, or replacement.

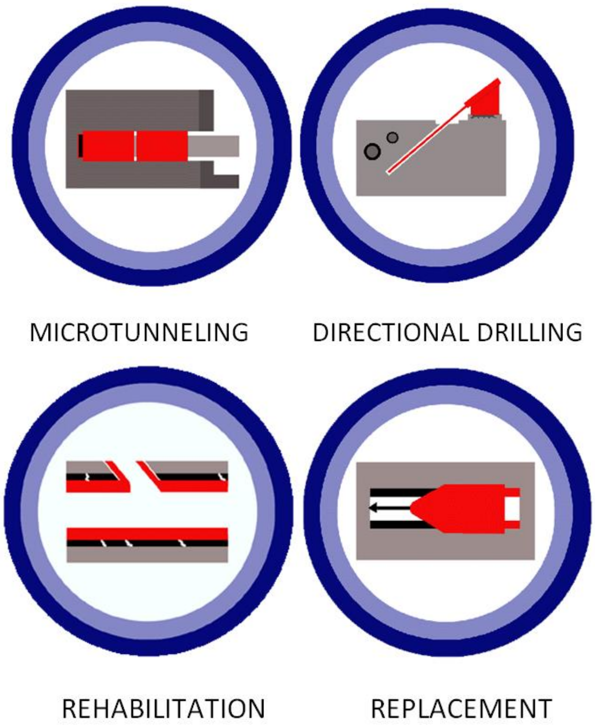

Figure 1. Trenchless Techniques

II. METHODS AND MATERIAL

1. Sections of Trenchless

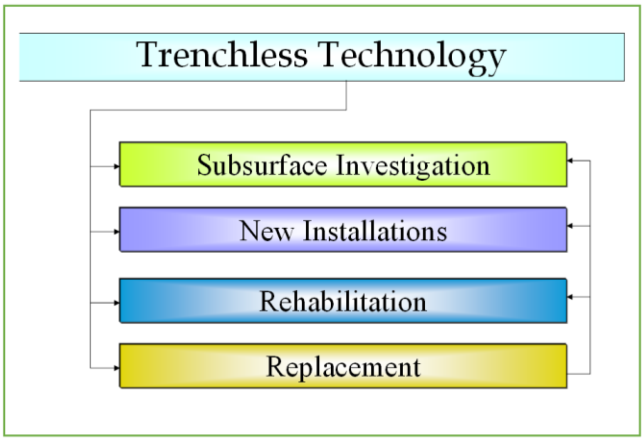

Figure 2: Flow chart of Sections

2. Subsurface Investigation

Objective

- Defining the lateral distribution and thickness of soil and rock strata within the zone of influence of the proposed construction.
- Defining groundwater conditions considering seasonal changes and the effects of construction or development extraction.
- Identifying geologic hazards, such as unstable slopes, faults, ground subsidence and collapse, floodplains, regional seismicity, and lahars.
- Procuring samples of geologic materials for the identification, classification, and measurement of engineering properties.

A. Step 1 - Gather Existing Information

- Structure Data
  - ✓ Bridge, building, road, wall, etc.
  - ✓ Type - stories, loads, materials, etc
- Known Soil Data
  - ✓ Your own knowledge of the area
  - ✓ Geologic or other maps
  - ✓ Other people
  - ✓ Aerial photos

B. Step 2 - Field Investigation

- Site Recon -Before you move any equipment to site, visit the site.
- A visual inspection can tell you a lot:
  - ✓ Site access
  - ✓ Existing structures
  - ✓ Evidence of old structures
  - ✓ Environmental hazards
  - ✓ Sinkholes
  - ✓ Topography
  - ✓ Condition of nearby structures

C. Step 3 – Laboratory Investigation

- Most common tests include:
  - ✓ Plasticity (atterbergs)
  - ✓ Sieve
  - ✓ Moisture
  - ✓ Unit Weight
  - ✓ Proctor
  - ✓ Strength tests (unconfined, direct shear, etc.)

D. Step 4 – Design

- ✓ The design process will take into account all data
- ✓ Consider loads, soils, type and use of facility, etc.
- ✓ GE often asks "what is needed" vs. what is calculated

Some of the main items conveyed to client:

- ✓ Types of soils
- ✓ Groundwater
- ✓ Recommended foundation type or options plus design and construction criteria
- ✓ Depth to bedrock
- ✓ Excavatability
- ✓ Soil compaction criteria
- ✓ Slope recommendations
- ✓ Retaining wall design
- ✓ Boring and Lab test results

E. Scope

The scope of the investigation will depend upon the size of the proposed construction area, i.e., a building footprint, or several to hundreds of acres, or square miles, and the experience of the investigator in the area. Do they have prior knowledge or is the area new to them? This text assumes that prior knowledge is nil or limited.

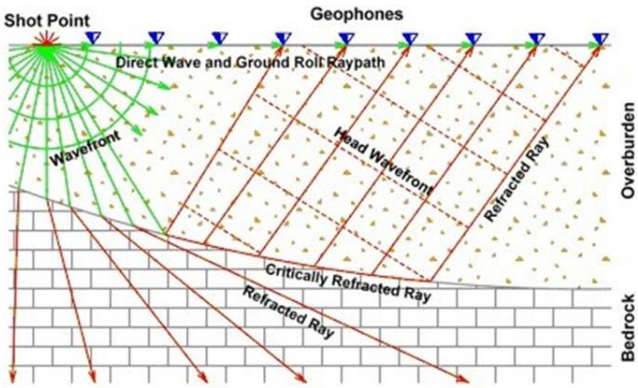

Figure 3: Seismic Refraction Geometry

F. New Installations

- Under remote controlled operations, subsurface passage can be developed by either:
  - ➢ Shifting soil sideways;
  - ➢ Cutting the soil mechanically and removing it axially; or
  - ➢ Fluid assisted soil cutting and removing it axially.
- New Installation Trenchless Techniques use these three hole creation mechanisms individually or in combination.

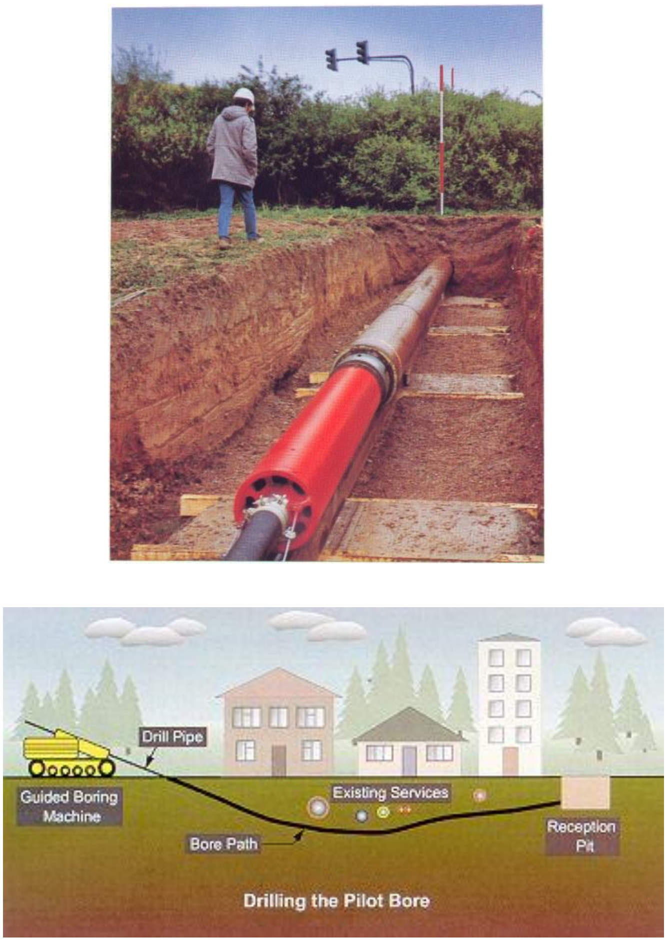

Figure 4: Impact Ramming

III. RESULTS AND DISCUSSION

1. Rehabilitation

- CIPP, FFP, DRP are trenchless pipeline rehabilitation techniques.
- CIPP is a liquid thermosetting resin-saturated material that is inserted into the existing pipeline by hydrostatic inversion.
- The FFP/DRP process utilizes a thermoplastic pipe which is folded or deformed to reduce the cross-sectional area, then pulled into place, expanded and rounded using heat or pressure, to conform to the internal shape and size of the existing pipe.

Figure 5 : Rehabilitation Process

2. Replacement

The most applicable to the following methods of trenchless pipe replacement:

- **Pipe Bursting**
  Using pneumatic, hydraulic expansion, or static pull systems techniques that fracture a pipe and displace the fragments outwards allowing a new pipe to be drawn in to replace the old pipe.
- **Pipe Implosion**
  A technique that fractures the pipe inwards prior to the outward displacement of the pipe fragments.
- **Pipe Splitting**
  Used to split open existing ductile pipes to allow a new pipe to be drawn in to replace the old pipe.
- **Pipe Eating**
  Uses a specially-designed variant of a microtunneling machine that excavates the old pipe in fragments and removes them rather than displaces them - the new pipe is jacked into place as in a microtunneling operation.
- **Pipe Reaming**
  Uses a specially-designed variation of the reaming process used in horizontal directional drilling to excavate the old pipe in fragments and removes them rather than displaces them - the new pipe is pulled into position behind the reaming head.
- **Pipe Ejection**
  The old pipe is jacked out towards a receiving manhole or excavation where it is broken up and removed the new pipe is used to eject the old pipe.

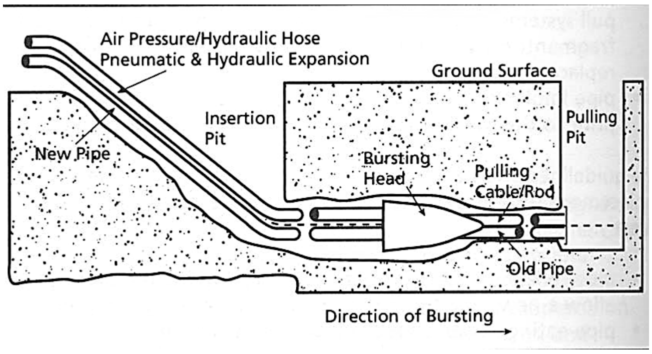

Figure 5: Replacement Process

3. Analyzing Indian Trenchless

✓ **Indian Trenchless Market**

India is highly dense in terms of population. As the population continues to grow, it is estimated that almost half of India's 626 districts will require upgrades in utility infrastructures. Considering this population growth, the trenchless market in India is theoretically around 50,000 km of infrastructure across a total urban area of 77,370 km2. Around 63 cities identified in JNNURM (Jawaharlal Nehru National Urban Renewal Mission) are considered to be a priority for development.

In an effort to reduce the environmental impact of developing and operating sewage treatment networks, underground interceptors constructed using trenchless methods are being viewed as a positive solution in densely populated cities, especially those located along river banks. According to the JNNURM plan, the total value of trenchless projects being developed in the 63 priority cities is around USD 23 billion.

Trenchless work has already been initiated in the cities of Delhi, Mumbai, Kolkata, Bangalore, and Hyderabad. Primarily, these projects are for installing water and sewer pipes and are being constructed using pipe jacking or micro tunneling methods. HDD has been used for Optical Fiber Cable (OFC) laying for telecom and internet service provider companies.

Pipe rehabilitation projects using trenchless methods as well as pipe ramming and pipe jacking projects are also being carried out in the cities of Delhi, Kolkata, Bangalore, Chennai, Hyderabad, Cochin, Ahmadabad, and other Tier-II cities. Although HDD is a fairly popular trenchless method in India, other methods are not as widespread based upon the number of machines currently in use. For auger boring, there are currently no more than 60 auger machines in use across India. For micro tunneling, there are less than 30 micro tunnel boring machines (MTBMs) in use.

✓ **The Primary Challenges Facing The Indian Trenchless Market Can Be Summarized As Follows**

- Lack of awareness about trenchless methods and their benefits;
- Cost comparisons against cut-and-cover methods that do not take into consideration the evaluation of social costs and benefits;
- A limited pool of specialty contractors skilled in trenchless construction, leading to monopolization of market; and
- Lack of supportive infrastructure.

4. Benefits of Trenchless Technology

Trenchless applications have achieved a very high level of precision due to the progressive development of equipment and method technology and this has made the execution of practically all types of supply and disposal lines possible, irrespective of their sizes or the geological and hydro geological limiting conditions in an ecologically friendly and enclosed method of underground construction.

Where employers have fully recognized and utilized the possibilities of this technology, they have not been slow in reaping the economic rewards. Crossings of major rivers for laying telecom cables and product pipelines for oil and gas across major rivers like Hooghly or Chambal at breakneck speeds have yielded good economic results for such employers. One look at such rivers and one can understand the importance and relative benefits of trenchless technology over the conventional construction methods.

A. By Using Trenchless Technology One Can Achieve Reduction of the Following

✓ Disruptions to traffic and movement.
✓ Danger to existing underground facilities while developing or managing networks.
✓ Easement requirements.
✓ Environmental impact - dust and noise.
✓ Potential for settlement damage.
✓ Potential of injuries due to open excavations.
✓ Required time & time related costs.

B. Other Benefits of Using Trenchless Technology Are As Under

- ✓ They help in the effective use of geological settings;
- ✓ Provisioning for future use and sustainability is enhanced by Trenchless techniques;
- ✓ One can achieve the maximization of underground developable space;
- ✓ Deterioration of underground networks can be contained;
- ✓ Unlike the open cut projects there are generally no hindrances over the entire project length;

Camouflage of the utility networks for security purpose can be done more efficiently.

5. Limitations of Trenchless Technology

Trenchless technique provides assistance to the utility developers and managers to execute works remotely. A substantial portion of work is done through mechanical means without physical entry of the operator at the exact work location. For an example in a micro tunneling and pipe jacking project the earth face of tunnel is excavated by the cutter and a slight error in the alignment or grade of the cutting shield can lead to tunnel/project deflection. Such errors can occur on account of any of the following causes:

A. Operator Failure

Operator skills are quite important. Untrained or undertrained operators may produce unsafe or failed structures. This is one of the most critical, but often ignored, aspects of any trenchless project. The fact is if a machine operator who is not properly trained on specific equipment operates the same, He may not be able to understand or feel the distress signals emanating from the equipment at the execution times and may operate the equipment in a completely incorrect way.

B. Specialized Nature

Trenchless techniques are State-of -art systems. Each projects needs to be conceived, planed, structured, designed, executed, and concluded in its entirely, incomplete or inadequate construction works will lead to unsafe or unsound structure.

C. Technique Selection

Improper or inadequate technology selection may lead to failures. Primary objective of these techniques is to develop, maintain or manage subsurface networks and there are several competing techniques that appear to be suitable for a project but the best suited technique is to be selected.

6. Technique Applicability

The development of trenchless technology was initially undertaken to meet specific needs in different industries and in different parts of the world. For example, research into micro tunneling in Japan was in response to a Government initiative aimed at increasing sewer services in large cities. Similarly, in Singapore, government regulations and the need to provide services in densely populated areas lead to the promotion and use of micro-tunneling. In Europe research into micro-tunneling was sponsored by the German government for use in large cities on the North German Plain were ground conditions were favorable.

In the United Kingdom, where the large towns and cities had been built during the industrial revolution in the 19^{th} century, the principal need was to replace and rehabilitate ageing sewers, water pipes and cast iron gas mains. In addition, the use of natural gas at higher pressures encourages the development of pipe-bursting techniques.

In North America horizontal Directional Drilling, developed from vertical oil wells after the reservoir yield reduced, became widely used for constructing long pipelines for the oil industry.

IV. CONCLUSION

In cities and urban areas water and sewage infrastructure and other utility services located underground in pipes or ducts are laid, repaired or replaced by the conventional trenching methods. The open cut trenching methods create road closures, traffic delays, noises and general disruption. This makes repair and rehabilitation of subsurface utilities difficult, particularly in areas congested with traffic and buildings. Lack of repair and rehabilitation of the pipeline for the water disruption and sewage systems lead to leakages and waste water seepages, resulting in the contamination of water distribution system and groundwater. These problems often give rise to related health and environmental impacts.

The demands for alternative technology lead to the emergence of trenchless Technology, which includes a family of methods utilized for installing and rehabilitating underground utility systems with minimum ground surface disruption and destruction as compared to open cut excavation methods. Trenchless technologies and methods provide an effective, environmentally sound alternative for the installation, maintenance and repair of underground utility services.

The appropriate application of trenchless Technology for resolving both Engineering and Environmental problems can be viewed as an environmentally sound technologies. In addressing urban sanitation problems, Trenchless Technologies have the potential to yield significant environmental and other benefits such as employment opportunities reduced inconvenience to commuters, reduced fuel consumption and improved traffic flow.

V. CASE STUDY OF PIPE RAMMING

Case Study: Khan Market, New Delhi, OFC (Optical Fiber Cable)
Project Name: Horizontal Directional Drilling.
Client: Mahanagar Telephone Nigam Limited (MTNL)
Requirements: Installation of 20cm diameter optical fiber cable to supply 4G line.
Distance: 100m
Crossing: Underneath the road and old Museum.
Pit Size: Launch pit 4.5m x 1.5m
Constraints: Fully enclosed Garden at the centre of the museum with all plant and equipment having to be transported through the public galleries to the job site. Cable to be installed to connect the enclosed garden to a service area in a basement 12m away. The cable route would be beneath the public gallery with installation being completed during the museum's opening hours. Space in the basement was extremely limited making any method requiring access to both ends of the bore impossible. The cable needed to be installed just 200mm below the buildings foundations.

Ground Conditions: Hard packed soil and gravel.
Installation Time: 2 Days

Trenchless Solution: To allow all equipment to be moved to the job site through the museum by man power (High impact force in relation to size and weight) and each 12m cable was divided into three 4m long sections. Based on the calculated trajectory of the 'Blind Shot' into the basement portable runners were placed in the launch excavation. Initial set-up was very quick allowing two complete 4m sections of cable to be installed by the end of the first day. Only 1 hour into the second day, welding of the final section of the first duct was complete and breakthrough into the basement was observed by a very happy client. Spoil removal was achieved by a combination of Air Pressure and High Pressure Jetting to remove final residues.

Figure 6: Pipe Ramming In V and A Mesum

VI. ACKNOWLEDGMENT

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