Advances in Trenchless Methods for Gravity Sewer Installation

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Outline

Overview of Methods and Recent Advances
  Auger Boring
  Pilot Tube Method
  Pipe Ramming
  Microtunneling
  Pipe Jacking

Questions
Horizontal Auger Boring (HAB) Defined

- Horizontal auger boring (HAB) is defined as a technique for forming a bore from a launch shaft to a reception shaft by means of a rotating cutterhead. Spoils are transferred from the face to the launch shaft by an auger rotating in a steel casing.

- The “ASCE Manual of Practice for Horizontal Auger Boring (HAB),” is currently under review with an expected publication in 2016.
Horizontal Auger Boring (HAB) Capabilities

• ABM’s were originally developed to cross under a two-lane paved roadway with an average length of 40-feet and a maximum length of 70-feet
• The average bore length range 300-feet, with some drives in excess of 600-feet
• Accuracy of methods is +/- 1% of the drive length
### Horizontal Auger Boring (HAB) Subsurface Conditions

<table>
<thead>
<tr>
<th>Ground Conditions</th>
<th>Applicability</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathered to unweathered rocks</td>
<td>S</td>
<td>Up to about 4,000 psi (28 MPa) of rock unconfined compressive strength using drag teeth excavation, and up to 25,000 psi (170 MPa) and above using disk cutters.</td>
</tr>
<tr>
<td>Soft to hard cohesive soils</td>
<td>S</td>
<td>Includes clays, silts and organic deposits; in soft soil, steering corrections is diminished and often not possible</td>
</tr>
<tr>
<td>Medium to dense sands and silts above groundwater</td>
<td>S</td>
<td>Careful installation with a recessed auger is required to limit the risk of overmining.</td>
</tr>
<tr>
<td>Very loose to loose sands and silts above groundwater</td>
<td>M</td>
<td>The risk of overmining exists with running sands.</td>
</tr>
<tr>
<td>Sands and silts below groundwater</td>
<td>M-U</td>
<td>May be marginal if a cohesive soil layers are expected to create a plug.</td>
</tr>
<tr>
<td>Cobbly and gravelly ground</td>
<td>M</td>
<td>Depends on the obstruction size and frequency, generally obstructions up to 30% of the casing diameter.</td>
</tr>
</tbody>
</table>

Legend: S= Suitable For Use, M= Marginal For Use, U= Not Recommended For Use
Horizontal Auger Boring (HAB) Advantages and Disadvantages

Advantages
• Cost effective
• Relatively Easy to mobilize and maintain
• Accommodates most ground types above groundwater
• Cased Installation

Disadvantages
• 2-Pass Installation
• Limited control of line and grade without assistance
• Not appropriate for use when groundwater present
Horizontal Auger Boring (HAB) Advances in Accuracy

- Steering attachment that is welded to the end of the casing
- Improves installation accuracy to +/- 4-inches irrespective of the drive length
HAB Cutting Head Adaptor Advances - Small Boring Unit (SBU)

- HAB is effective in soil and weak rock (4,000 psi)
- The small boring unit (SBU) is a an adaptor that is used with the ABM
- SBU is welded to the front of the steel casing
- SBU is effective in rock having a UCS ranging from 4,000 psi up to and exceeding 25,000 psi
HAB Cutting Head Adaptor Advances - Small Boring Unit (SBU)

• There are four types of SBUs available:
  – small boring unit–auger (SBU-A)
  – motorized small boring unit (SBU-M)
  – small boring unit rockhead (SBU-RH)
  – small boring unit remote controlled (SBU-RC) (Most Recent)

• The SBU is available in sizes ranging from 24 to 78 inches in diameter

• Accuracy +/- 1 inch when active steering is available
# Horizontal Auger Boring (HAB) With SBU Subsurface Conditions

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<tr>
<th>Ground Conditions</th>
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<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Weathered to unweathered rocks</td>
<td>S</td>
<td>Up to 25,000 psi (172 MPa) of rock unconfined compressive strength.</td>
</tr>
<tr>
<td>Soft to hard cohesive soils</td>
<td>U</td>
<td>Not a suitable technology for full face soil applications.</td>
</tr>
<tr>
<td>Medium to dense sands and silts above groundwater</td>
<td>U</td>
<td>Not a suitable technology for full face soil applications.</td>
</tr>
<tr>
<td>Very loose to loose sands and silts above groundwater</td>
<td>U</td>
<td>Not a suitable technology for full face soil applications.</td>
</tr>
<tr>
<td>Sands and silts below groundwater</td>
<td>U</td>
<td>Not a suitable technology for full face soil applications.</td>
</tr>
<tr>
<td>Cobbly and gravelly ground</td>
<td>M</td>
<td>Required to be in a cemented matrix free of groundwater.</td>
</tr>
<tr>
<td>Mixed-face of soil and rock</td>
<td>M</td>
<td>Transition from soil to rock and then back should be limited to soils that are slightly cemented with limited cohesion.</td>
</tr>
</tbody>
</table>

Legend: S = Suitable, M = Marginal, U = Not Recommended
Small Boring Unit (SBU) Advantages and Disadvantages

Advantages

• Cost effective
• Precise installation (Excluding the SBU-A)
• Relatively easy to mobilize and maintain
• Can accommodate some mixed ground conditions

Disadvantages

• 2-Pass Installation
• Used above the groundwater
• For use mainly in rock
Pilot Tube Method (PTM) Defined

• Also know as Pilot Tube Microtunneling (PTMT), Pilot Tube Auger Boring (PTAB), and Guided Auger Boring

• ASCE defines the pilot tube method as a multistage method of accurately installing a product pipe to line and grade by use of a guided pilot tube followed by upsizing to install the product pipe

• The “ASCE Manual of Practice for Pilot Tube and Guided Boring Methods (PTGBM),” is currently under review with an expected publication in 2016
Pilot Tube Method (PTM) Background

• PTM was first introduced in the US in 1995
• It is a multistage method of accurately installing a product pipe by use of a guided pilot tube, followed by progressive upsizing to install the product pipe
• Suitable for pipe diameters up to 48 inches and drives approximately 400 feet in length when not combined with other methods
• For use in displaceable soils
Pilot Tube Method (PTM) Operation

• Is a hybrid of horizontal directional drilling (HDD), microtunneling, and horizontal auger boring (HAB) methods

• The steering head and pilot bore advance followed by multiple passes of hole openers is similar to the HDD methods while the guidance system is similar to that used in microtunneling. The spoils removal system is similar to that used in HAB
Pilot Tube Method (PTM) Capabilities

• PTM is used to install concrete, clay, polycrrete, FRPP, and steel pipe ranging in diameter from 4 to 48 inches with a drive length of up to about 400 feet

• A few recorded drives have been greater than 500 feet, but length is dependent on subsurface conditions and pipe diameter

• Accurate up to +/- 0.25 inches
Pilot Tube Method (PTM) Drill Head Adaptor Advances

• Recent advances in technology that allow for installations in rock using the Akkerman Pilot Tube TriHawk Adapter to work with TriHawk® drill bits

• For use in ground conditions having a UCS up to 18,000 psi

• Accuracy with the method is within +/- 0.25 inch at 300 feet but is reliant on the capability of the theodolite and the operator’s skill
Pilot Tube Method (PTM) Used With Other Methods

• Used in conjunction with HAB and is called Guided Auger Boring System (GAB)
• The pilot is advance using the theodolite to the receiving shaft
• An adaptor is used on the end of the auger that follows the pilot
• Increases accuracy of HAB from +/- 1% of drive length to +/- 0.25 - inch at 300-feet
• Can be used with other trenchless methods
# Pilot Tube Method (PTM) Subsurface Conditions

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<td>Weathered to unweathered rocks, and very dense and hard soils with N-value of 50 blows per foot (30 cm) or greater</td>
<td>M</td>
<td>Possible only with recently developed Drill Head Adaptor technology.</td>
</tr>
<tr>
<td>Soft to hard cohesive soils</td>
<td>S</td>
<td>Soils must be displaceable and have an N-value less than 50 blows per foot.</td>
</tr>
<tr>
<td>Medium to dense sands and silts above groundwater</td>
<td>S</td>
<td>Soil must be displaceable</td>
</tr>
<tr>
<td>Very loose to loose sands and silts above groundwater</td>
<td>S</td>
<td>Lubricant is required.</td>
</tr>
<tr>
<td>Sands and silts below groundwater</td>
<td>S-M</td>
<td>Satisfactory performance with heads less than 10 feet; marginal performance over 10 feet.</td>
</tr>
<tr>
<td>Cobbly and gravelly ground</td>
<td>M-U</td>
<td>Probe cannot bypass obstructions having an N-value greater than 50 blows per foot without drill head adaptor.</td>
</tr>
</tbody>
</table>

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PTM Advantages and Disadvantages

Advantages

• Precise installation
• Small shaft diameter
• Relatively easy to mobilize and maintain
• Compatible with most pipe materials
• Accommodates most ground types above and below groundwater

Disadvantages

• 2-Pass to 3-Pass Installation
• Limited diameters without use of other equipment
Pipe Ramming Defined

• Pipe ramming is generally considered to be a non-steerable system for driving a steel casing using a percussive hammer from a drive pit

• The casing may be either closed-end for small-diameter pipes, usually 4 to 8-inches or open-ended for larger diameter pipes up to 144-inches at a length up to 300 -feet
Pipe Ramming Capabilities

• Pipe ramming is used below railroad and highway embankments

• Suitable in challenging soft soils or where there are cobbles and boulders smaller than the diameter of the casing

• The method is non-steerable making it unsuitable where grade is critical

• Accuracy of method is +/- 3% of the drive length
Pipe Ramming Advances

• Have been used in conjunction with pilot tube method

• A guide attachment is welded to the front of the pipe to be rammed improving accuracy of the installation
Microtunneling Defined

- ASCE’s Standard Design and Construction Guidelines for Microtunneling (2015) defines microtunneling as a trenchless construction method for installing pipelines that meets the following criteria:
  - Remotely operated from the surface
  - Utilizes a guidance system
  - The pipeline is constructed by using a jacking system for thrust
  - Continuous pressure is provided to the face of the excavation to balance groundwater and earth pressures
Microtunneling Capabilities

• Typical installations lengths from about 200 to 500 feet
• Longer installations are achievable depending diameter and jacking force requirements
• Curved installations are possible but are technically challenging and require a customized pipe design making the process (relatively) expensive
• Most installations completed in North America are straight
Microtunneling Capabilities

• Common pipe material include RCP, steel pipe, ductile iron pipe, FRPP, VCP, and polymer concrete pipe (PCP)
• The typical sizes 6 to 138 inches with the most common range being 24 to 60 inches
• Used for gravity lines where a high degree of accuracy (+/- 1-inch) is required or when low strength or saturated soils are anticipated or groundwater is a concern
Microtunneling Guidance System Advances

• Total Guidance System (TGS) is a monitoring system used with extended tunnel lengths and alignments with curves

• Range of distance between stations can be achieved, on average 1,000-3,500-feet

• The station continuously tracks the exact X and Y positioning of the cutter head as well as horizontal and vertical deviation
Pipe Jacking Defined

• ASCE defines pipe jacking as a system using hydraulic jacking to directly install pipes behind a shield machine to form a continuous pipe string in the ground

• It is a trenchless technique commonly used to install gravity pipelines including sewers and storm drains underneath highways, waterways, and railways
Pipe Jacking Operation

• Pipe jacking involves pushing pipes through the ground, from a launch shaft towards an receiving shaft, while simultaneously excavating at the face inside a jacking shield or a tunnel boring machine (TBM)

• The rate of excavation must be compatible with the rate of jacking to avoid heaving or subsidence at the ground surface
Pipe Jacking Capabilities

• Pipe jacking has several advantages, including the ability to install the product pipes within 1-inch on line and grade without the need for a casing

• Economical for installing pipes ranging from 48 to 120-inches in diameters
Pipe Jacking Advantages and Disadvantages

• Larger diameter pipes and rectangular boxes can be installed

• Pipe jacking allows access to the face of the excavation to remove boulders or cobbles, minimizing the need for a rescue shaft

• Disadvantage is that personnel access inside the jacking shield is required to operate the equipment and facilitate excavation at the face, and dewatering is needed in granular soils below the groundwater table
Summary

• Many techniques available for trenchless installation for gravity applications

• Dependent on ground conditions and project constraints

• New developments and advances made within the trenchless industry are made routinely and are primarily based on project requirements and contractor needs