The North American Society (NASTT) and the
International Society for Trenchless Technology (ISTT)
International No-Dig Show 2009

Toronto, Ontario Canada
March 29 – April 3, 2009

Paper C-1-03

FIELD CHALLENGES AND SUCESSES WITH PILOT TUBE MICROTUNNELING

Michelle Ramos, L.E.G., P.E.[1]

[1] Staheli Trenchless Consultants, Bothell, WA

ABSTRACT: This paper presents two case studies of the pilot tube microtunneling method (PT), the challenges that were faced during construction, and how those challenges were overcome. The paper details the project designs, the intent of the engineer, and how the contractor made modifications to the design during construction. The paper also compares the use of PT in two very different geotechnical environments and provides recommendations for future projects.

For one project, trenchless construction was only considered after open-cut construction in dry, running sands proved prohibitively difficult. That project involved finishing the last 1,000 feet of the 10-inch HDPE gravity sewer line using a hybrid PT/HDD construction method. The contractor chose to use only the first phase of PT machine to advance the pilot bore and then continue the installation using traditional HDD techniques.

A similar hybrid PT/HDD approach was proposed by the contractor on another project with distinctly different soils. Based on the success of the first project, the contractor's approach was accepted. The second project involved installing approximately 1,100 feet of 10-inch diameter HDPE waterline in compact gravelly sand.

Lessons learned from the construction of these projects will be discussed and recommendations for future hybrid PT projects will be explored.

1. TRADITIONAL PILOT TUBE METHOD

Pilot tube microtunneling, also known as Guided Boring or the pilot tube method (PT), is a trenchless construction technique for small diameter pipe installations that uses a guidance system within an angled head to achieve precise line and grade.

Traditional pilot tube microtunneling is a three-phase construction techniques that uses a

Figure 1: Pilot Tubes

compact jacking unit and frame to install a small diameter pilot bore from the jacking shaft to the reception shaft. After the jacking frame and guidance system are installed in the jacking shaft and properly aligned, the first stage involves pushing the pilot tube to the reception shaft. The 4.25-inch outside diameter pilot tube is hollow and comes in 2.5-foot sections (Figure 1). On the leading edge of the pilot tube is a steering head, which is angled to allow for grade and alignment adjustments. Inside the steering head is an illuminated target with a long tail that points toward the bias of the steering head (Figure 2). The guidance system camera views the target in the steering head, and projects the image onto a LCD monitor in the jacking shaft (Figure 3). The operator keeps the guidance system aligned on the target as the pilot tube is pushed through the ground. Once the pilot tube reaches the reception pit, it is double checked for proper line and grade.

Figure 2: Steering Head

The second phase involves placing a reaming head, augers and a section of casing behind the last pilot tube. The casing size is dictated by the size of the product pipe. For example, a casing would require a 12-inch outside diameter to accommodate the 10.75-inch outside diameter product pipe. The auger head provides a small overcut to allow the casing to be installed with reduced ground friction. The augers and the casing are pushed to the reception shaft. As they are advanced along the pilot tube path, the pilot tubes are pushed out of the bore into the reception shaft, keeping the augers on grade. The spoils from the augers are returned to the jacking shaft for removal.

Figure 3: LCD Monitor in Jacking Pit

In traditional pilot tube microtunneling, when the reaming head reaches the reception shaft, the product pipe is then placed behind the casing and the product pipe is used to push the casing and augers into the reception shaft. With the traditional method, the product pipe is installed by pushing and is limited to concrete, clay, polycrete, or steel pipe.

2. HYBRIDS OF THE PILOT TUBE METHOD

Projects using a “hybrid” of the Pilot Tube method are becoming more common as contractors and engineers become familiar with the benefits and versatility of the system. Hybrid Pilot Tube methods use the pilot bore phase to set line and grade then switches to another trenchless method to install the product pipe. For example, using the pilot bore method with auger boring, pipe raming or Horizontal Directional Drilling.

3. ALASKA PROJECT

This project involved installation of over 1,100 feet of water line within a narrow utility-congested alley. Guided boring or pilot tube microtunneling (PT), was specified by the design engineer and was modified during construction by the contractor. The contractor proposed a hybrid PT and

HDD installation method that utilized the pilot phase of PT with the reaming and pullback phases of HDD.

3.1 Background

This project was severely constrained by existing utilities and home accesses. The residences in this area all face the main streets (G Street and H Street) with driveway access through the rear alley. The alley contains utility main lines and service lines, including an existing 6-inch diameter wire-wrapped wood stave pipe that has experienced recent failures.

Anchorage Water and Wastewater Utility needed to install a new 8-inch diameter pipe along the G/H Alley right-of-way (r.o.w.) to replace the existing wood stave pipe. The r.o.w. was only 20 feet wide, was the main access for the homes along the alley, and contained four below-grade utilities as well as overhead power. The water line was located 10 to 11 feet below grade in dry sand with gravel. Various trenchless construction options including HDD, auger boring, pipe bursting and PTMT were considered due to the presence of many utilities, the lack of available room within the narrow r.o.w. to perform open-cut work, and the regular use of the alley by neighboring residents.

HDD was originally considered to replace the existing water line. However, because of the line and grade control needed to install the water line in close proximity to the other utilities in the r.o.w., the frac-out potential, and the presence of gravelly soil, HDD was not selected as the preferred construction method for this project.

Replacement of the water line by auger boring construction was also considered for this project. However, because the alley contains many utilities, there was insufficient space to install the size jacking and receiving pits required without temporarily relocating many of the existing utilities. A significant constraint imposed by one of the utilities would have required a complete replacement of the entire length of their pipeline for any portion moved, therefore, auger boring was not chosen as the best trenchless option for this project.

PTMT was selected as the preferred construction method since it can be precisely installed in congested right-of-ways. However, since HDPE pipe does not respond well to compression, the project was designed to have the HDPE pipe pulled into place using the casing pipe as a pulling head.

3.2 Submittal Process

This project went out to bid in early 2008 and was awarded to Trenchless Construction Services (TCS) from Arlington, Washington. As part of the submittal process, the contractor suggested using a hybrid Pilot Tube/HDD process. The contractor proposed using the pilot tube method to establish line and grade then switch to an HDD rig to complete the reaming and pull back. Use of this technology was new to the contractor, the engineer, and the owner but promised to provide a number of benefits if successful.

During the submittal phase of the Alaska project, TCS started a project in Washington for which they had proposed using the hybrid Pilot Tube/HDD process. Since construction of the second project preceded the Alaska project, Staheli Trenchless Consultants visited the project during the critical phases to better understand the process, the technology, and the applicability to the Alaska project.

4. WASHINGTON PROJECT

This project was for installation of 10-inch HDPE gravity sewer line and had been started using open cut construction. However, due to the presence of dry running sands, open cut construction was proving prohibitively difficult. TCS proposed completing the last 1,000 feet of the project using the hybrid PT/HDD construction method.

The pilot tube unit and jacking frame was placed in an approximately 10 foot by 20 foot pit (Figure 4) and launched. The contractor used a Boretec pilot tube machine and frame. The drives were each about 300 to 350 feet long.

Figure 4: PT Unit and Jacking Frame

Figure 5: HDD Machine in Pit

Once the pilot bore had been successfully pushed on line and grade from the launch pit to the reception pit, the pilot tube jacking frame was removed from the pit and replaced with a Horizontal Directional Drill (HDD) machine. The HDD machine was set up to drill horizontally (Figure 5). The HDD drill rods were connected to the Pilot Tube drill rods with an adapter. The HDD drill rods were than used to push the Pilot Tube drill rods into the reception shaft where they were manually disassembled and removed from the reception shaft. Once the HDD drill rods reached the reception shaft, a drilling head was attached to the end of the drill rods and an HDD bore was drilled on a curve from the reception shaft to the surface. Once at the surface, a 14-inch reamer was attached to the drill rods (Figure 6) with the pre-welded length of HDPE pipe attached to a pulling head with a swivel between the reamer and the pulling head (Figure 7).

Figure 6: Reamer on HDD Rods

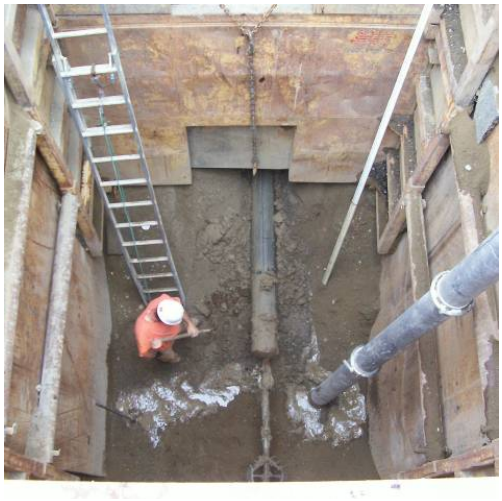

Figure 7: Reamer, Swivel and HDPE Pipe

Figure 8: HDPE Pipe being pulled in

Figure 9: Site Set-up

During the reaming and pullback, drilling mud was circulated through the drill pipes to aid in spoil removal. The HDPE pipe was pulled through the reception shaft to the launch shaft for completion of the HDPE product pipe installation (Figure 8). The drilling mud was removed from the reception pit and hauled off-site by a vac-truck (Figure 9).

4.1 Lessons learned from the Washington Project

- It can be time consuming to place the PT machine in the pit to launch, then replace with the HDD machine, then remove the HDD machine and then replace the PT machine in the pit to launch the opposite direction.
- It can be unwieldy to have an HDD drill rig in a pit. All support equipment is top-side and needs to be run down to the rig.
- For short runs and relatively small sizes, one-time use and then removal of drilling mud is appropriate.
- It can be difficult to initiate the curve from the reception shaft to the surface because of the lack of reaction soils in the reception pit. This resulted in a fairly long distance from the reception shaft to the exit on the surface.

- The portion of the bore from the surface to the reception pit needs to be addressed to ensure the residual open bore does not induce settlement of the roadway.

5. THE ALASKA PROJECT… continues

Now that the HDD/PT hybrid process had been vetted, the equipment was mobilized to Alaska. Some of the lessons learned in Washington were incorporated by the contractor into the equipment set-up and layout.

The pilot tube machine and frame was set-up in the jacking pit and the pilot bore advanced to the reception pit. Once the pilot bore was to the reception shaft, the pilot tube frame and machine were removed from the jacking shaft. An HDD rig was set-up on the ground surface back from the reception. Since the Washington project had shown that initiating the bend from the reception pit to the surface can result in a relatively long distance from the pit to the surface and since the depth to the water line was shallower, the contractor choose to open cut a sloped path for the drill rods (Figure 10). Once the drill rods from the HDD rig were advanced to the reception shaft, the HDD drill rods and the Pilot Tube Drill rods were connected and the HDD drill rods proceeded to push the Pilot Tube drill rods out of the bore and into the launch shaft.

Figure 6: Sloped Path for Drill Rods

Figure 7: Shredder Reamer

The surface mounted HDD rig then advanced the HDD drill rods through the pilot bore. Upon reaching the PT launch pit, a reamer was attached at the launch pit, and the alignment was back reamed and forward reamed using the HDD rig (Figure 11). Drilling mud was used to assist in removal of spoils from the bore and to help keep the bore open. Since the pilot bore had already been established, high the mud pressures were not needed to circulate the drilling mud. Similar to the Washington project, the drilling mud was not re-circulated but was vacuumed out of the pits and removed off site.

Once the bore had been reamed, a standard slant-head HDD drill bit was placed on the drill rods and a bore path was drilled from the launch pit to the surface.

The HDD rig was moved from near the reception pit to the other end of the drill stem where it was sticking out of the ground. The HDD rig was then attached to the drill rod and the pre-fused HDPE pipe string was maneuvered into position in the layout area (Figure 12). The pulling head with swivel

Figure 9: HDPE pipe being pulled into the bore

Figure 8: HDPE pull complete

was attached to the HDD drill rods and the HDPE pipe was pulled into the bore using the HDD rig (Figure 12). The pull back of the HDPE pipe was completed between the two pits. Once the pulling head and the HDPE pipe were fully in the launch pit (Figure 13), the pull back stopped and the pulling head was released from the HDD drill rods. The drill rods were then retracted to the rig leaving only a small pilot bore between the pit and the surface. This resulted in far less disturbance to the soil between the launch pit and the surface and greatly reduced the potential impacts to adjacent utilities from construction or long-term settlement of a 15-inch reamed bore path.

For the next run, the contractor placed the PT machine and frame in the next launch pit along the alignment and used the reception pit from the first run and the reception pit for the second run.

5.1 Lessons learned from the Alaska Project

- Keeping the HDD rig on the surface, rather than in the pit made moving the machine around less time consuming.
- Pulling back the HDPE pipe from the reception pit side, resulted in no large diameter reamed bore that would need to be abandoned within the right of way.
- "Leap-frogging" the pilot tube machine and frame with the HDD machine reduces the overall time for the project by allowing the Pilot Bore to be advanced while the HDD is reaming and pulling back.

Figure 10: HDD rig pulling in pipe

5. CONCLUSIONS

Typically with PTMT, the slowest part is the excavation and advancement of the casing. By switching over to the HDD system for reaming and pullback, the contractor was able to speed up these steps. Combining Pilot Tube technology with Horizontal Directional Drilling allowed for HDPE pipe to be installed with good line and grade control, close to existing utilities and near the surface with no frac out.