Choosing Pilot Tube Microtunneling Over Open-Trench Construction

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Sergeant Bluff, located along the Missouri River in western Iowa, is a community of 4,227. In 2009 the City moved forward with the First Street Lift Station Elimination and Sewer Project, which was planned to eliminate an aging and costly lift station by installing 4,000 linear feet of gravity trunk line sanitary sewer. The City critically evaluated installation methods, and estimated costs for open-trench and trenchless options.

Estimates for both options were presented to the City in February of 2009. The open-cut method's estimated cost was $1.125 million. The trenchless option was estimated at $225,000 (20%) more.

The City also considered each design option's impacts – including disturbance to traffic, condition of existing pavements, and conflicts with existing utilities. The project area included Sergeant Bluff's main east-west traffic corridor (with an average traffic count of 7,100 vehicles per day) and the primary corridor for student pickup and drop-off at a pre-kindergarten through fifth-grade school.

In the end, the City cited the following reasons as the drivers for the decision to select the more expensive, trenchless guided boring method of Pilot Tube Microtunneling (PTMT): potential cost overruns of open-trench construction; open-trench would require replacement of the entire street; the project corridor was critical for school traffic; existing utilities would be better protected using trenchless technology; and dewatering requirements at each shaft versus along the entire trench would better limit risk.

For the City of Sergeant Bluff, the value of maintaining traffic flow for the nearby school while limiting both the risks associated with dewatering and the potential for cost overruns made PTMT worth the investment.

"We're seeing more municipalities make the choice to install a premium pipe for

12-by-18-foot rectangular jacking shaft installing 15-inch pipe the benefit of a longer service life," said Jeff Boschert, president of the National Clay Pipe Institute. "The low-impact, high-accuracy installation made possible by the pilot tube method gives system designers and engineers greater control and more options. The longer life of vitrified clay serves the long-term interests of the community."

The project, awarded to Minger Construction of Chanhassen, Minnesota, consisted of 15- and 21-inch gravity sanitary sewer lines installed at depths up to 23 feet. The soil conditions encountered included silty clays, lean clays and poorly graded sands with blow counts ranging from 2 to 21. The contractor tunneled from 16-foot-diameter working shafts, with a three-step pilot tube installation process utilizing both powered reaming heads and powered cutter heads in the final step.

Project Challenges

A number of obstacles were encountered along the way that reinforced the wisdom of the selection of PTMT for this project. The first significant challenge presented in the design phase: Slopes for the sewer exceeded the trenchless standard of the Iowa Department of Natural Resources (IDNR).

"The total allowable vertical tolerance for this project was 1.75 feet," said Aaron Lincoln, project manager for Veenstra & Kimm, Inc. "The standard accepted bore and case vertical tolerances allowed for over five feet of variance. Without IDNR accepting the tolerances of pilot tube microtunneling, the only means for construction would have been open-cut."

Veenstra & Kimm, Minger Construction and Akkerman, Inc. documented the accuracy of the guided bore machine for the IDNR using vertical tolerances of just 1/4-inch per 300 feet of tunneling, or a total of one foot for the entire project. This pin-point line and grade accuracy, consistently achieved using this installation method, was the key driver in the IDNR's decision to grant a construction variance.

Record-breaking floods along the Missouri River in 2011 provided the second major challenge by raising the water table significantly above normal levels. The pilot tube method allowed for isolated dewatering at jacking and receiving pits, eliminating the need for dewatering along the entire length of an open trench. Groundwater monitoring wells were installed throughout the project to help document the elevations during the project.

A third project hurdle, resulting from the increased water table, was the failure of an existing gravity sewer located near but upstream of the project. After multiple emergency pipe collapses, the success of the ongoing project made extending the scope of the PTMT work the logical solution. As a result, Minger

Jacking shaft installing 21-inch pipe in the final phase of the installation

Construction replaced the nearby failed trunk line with a 1,330-feet parallel line, without extending the original project completion date.

The Method Used

The tunnel pipe installation began with the excavation and construction of jacking and receiving shafts. All tunnel shafts were excavated with a Komatsu 200- or 400-track hoe with conventional bucket attachment. These shafts were lined with either a 16-foot-diameter steel caisson or a 12-by-18-foot conventional trench box. The contractor fabricated the caissons, with bolted connections and doors for pipe entrances and exits, in their shop. The bottom of each shaft was lined with a base stabilization Geogrid fabric beneath a minimum of 18 inches of crushed stone to stabilize the jacking frame and prevent uplift. This stabilized base was left in place beneath the permanent manhole structure to serve as a foundation upon completion of the tunnel drives.

An Akkerman 4812 guided boring machine was utilized to perform all steps of the pilot tube microtunnel process. This unit had a jacking capacity of 200 tons, 100 tons of pullback capacity, and 20,000 foot-pounds of rotational torque.

Installation of the 100-millimetre (four-inch) pilot tubes on line and grade was the first step. With 400-foot drive lengths, accuracy of 6 mm (1/4 inch) or better was achieved for all of the drives.

Next, a 16-inch-OD reaming head followed the path of the pilot tube. The front of the reaming head fastened to the last pilot tube in the same manner the pilot tubes fasten to each other. Following the reaming head were 16-inch-OD thrust (auger) casings which transported the spoil (displaced ground around the pilot tubes) to the jacking shaft for removal. During installation of the 16-inch casings, the pilot tubes were advanced into the reception shaft and were disassembled as the casings were installed. This step was complete when the reamer and auger casings reached the reception shaft and all spoil was removed from the bore.

The final (third) phase of the installation varied by the size of the final product pipe. For the 21-inch-diameter line, a powered cutter head (PCH) was installed behind the auger casings and advanced by product pipe. The PCH increased the bore to match the 24.5-inch OD of the vitrified clay jacking pipe. The soil remaining around the previously installed 16-inch-OD auger casings was taken into the PCH and discharged via the reception shaft by reversing the auger flight direction. As each section of auger casing was removed from the reception shaft, a section of product pipe was installed in the launch shaft until the process was completed.

For the 15-inch-diameter line, a powered reaming head (PRH) was installed behind the auger casings and advanced by product pipe. The PRH works in the same

Installing 21-inch pipe in the final phase of the installation manner as the PCH but without a rotatable cutter face. This PRH increased the bore to match the OD of the 15-inch pipe at 20 inches. The remaining soil around the previously installed 16-inch-OD auger casings was taken into the PRH and discharged via the reception shaft by reversing the auger flight direction. The final 15-inch product pipe was then installed directly behind the PRH, providing the axial force required for advancement.

Unique to this project was a newly designed and built PRH assembly. Patrick Minger, president of Minger Construction, modified the PRH unit by relocating the hydraulic motor outside of the unit itself. The Minger Construction fabrication shop designed and built a frame which housed the hydraulic motor used to drive the auger flights. This "powered frame" was installed in the receiving shaft and connected to the auger flights, eliminating the need for staging the product pipe with hydraulic hoses to power the motor. This new design significantly decreased the staging time required and increased productivity in the final installation phase.

"The efficiencies we were able to achieve in the final phase make this method an even more competitively priced, attractive option," according to Minger. "We will be using this method again on future installations."

Not all communities have the option to specify premium products or premium installation methods, but for the City of Sergeant Bluff it was the right choice. The decision was thoroughly evaluated, and the community authorized the trenchless approach to maintain major traffic patterns, protect existing utilities, eliminate unnecessary pavement replacement, limit the likelihood of cost overruns and greatly reduce dewatering requirements.

This article is condensed from a paper presented at NASTT's 2013 NO-DIG Show.

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