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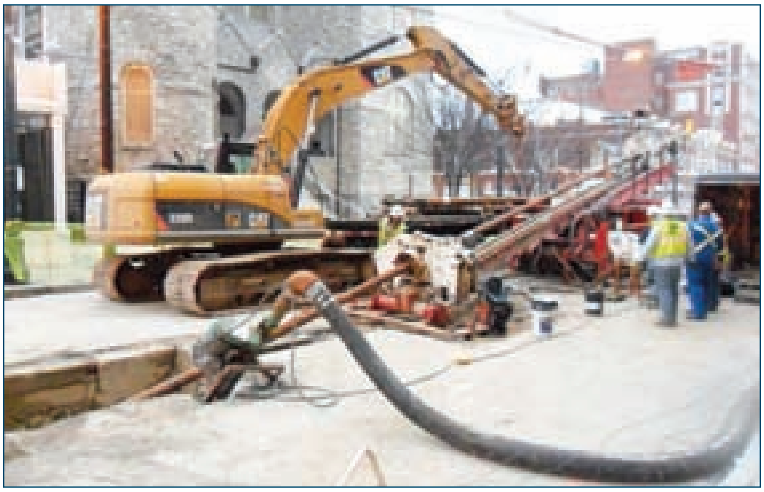
Lessons from the Streetcar

The use of trenchless technology in urban settings is firmly established as a valuable tool in the utility industry's toolbox, and this horizontal directional drilling (HDD) project demonstrates how well it can succeed



One of the access pits for the HDD bore

> "Strategic planning and co-operative relationships between the owner, contractor and design engineer ensured the success of the project"

The 2.7-mile (4.3km) Atlanta Streetcar project, completed in 2015, reconnected downtown Centennial Park with several historic sites isolated from the city centre by interstate highways.

The project included relocation of a 115kV electric circuit below historic Auburn Avenue, using a 1,860ft-long (567m) HDD completed on behalf of Georgia Power. The high-pressure fluid-filled (HPFF) cable duct replaced a direct-buried power line installed in 1959 that was located directly beneath the new streetcar trackbed.

Strategic planning and co-operative relationships between the owner, contractor and design engineer ensured the success of the project, despite its challenging urban location. This article conveys successful lessons for other engineers/owners considering an urban HDD installation.

GEOLOGIC SETTING

The project site is located in the Outer Piedmont of the Appalachian terrane, a major physiographic region extending from Montgomery, Alabama, to Philadelphia, Pennsylvania, and eastward towards the Atlantic Ocean.

The site 'soils' were derived from extensive in-place weathering of Paleozoic Appalachian bedrock. The high-grade feldspathic and quartz-rich metamorphic and igneous rocks (schists, gneisses, mylonites and granite intrusives) have weathered in place from long-term exposure, weakening the rock to a soil-like composition that still exhibits relict rock fabric. Termed 'saprolite' or 'residuum', it is commonly classified as a low to high-plasticity silt to clay with variable sand content and hardnesses.

ROUTE CHARACTERISATION

Adequate ground characterisation often determines the ultimate success of a trenchless project, and urban locations are no different. Haley & Aldrich, the geotechnical engineer and trenchless designer-of-record, used specialised techniques to supplement conventional soil and rock core test borings:

- Soil thermal resistivity was needed for ampacity calculations and cable derating by the electrical-cable designers, which measured potential soil desiccation created by cable operating temperatures. The goal was to prevent overheating that could lead to cable thermal overload and failure.
- Geophysical seismic refraction and reflection techniques along the entire drill path helped to refine the vertical HDD drill path and stay within softer, highly-weathered rock zones (shown as Layer 2) rather than harder bedrock. Drilling in harder rock would entail larger machinery and a longer construction period for pilot-hole drilling and reaming, lengthening the construction duration and impact on the neighbourhood, and increasing the project cost.
- Extensive subsurface utility engineering (SUE) was performed early in the design process. Numerous urban utilities were present at both HDD entrance and exit ends, including electric transmission ducts and service connections, natural-gas lines, sewer, telephone, water, fibre-optic cables and various stormwater conduits. Vacuum truck 'potholing' also found old trolley-car rails and wooden crossties, and the HDD drill path had to be extended about 180ft due to other unmarked utilities encountered at the start of construction.

Working at night on the Atlanta project

Map of the Atlanta Streetcar route and the Auburn Avenue HDD project

SETTING THE STAGE

Drilling in an urban setting posed a number of challenges, including a pipe laydown and fabrication area 0.25 miles away from the entry pit. The site was near Georgia State University, Hughes Spalding Children's Hospital, historic buildings and active businesses, so road closures and safe pedestrian walkways needed to be maintained.

CONSTRUCTION

W.A. Chester was the general contractor that engaged Mears Group to install the HDD segment of the project. Mears initiated HDD work in January 2013 and completed the pipe pullback in mid-February 2013, after 23 days of work. The drill alignment was down the centre line of Auburn Avenue, with a vertical grade change between HDD entry end (east) and exit end (west) of about 68ft.

Mears used an 'intersect' drilling method by drilling uphill, from east to west, and then repositioning the HDD rig at the exit end. This approach provided more torque for the backream through a zone of harder rock near the exit end, and mitigated potential drill-fluid losses (frac-out) from the borehole where there was thin soil cover but high annular fluid pressures.

Twelve-inch steel pilot casings were encased in flowable concrete fill at each drill end 'mud pit' to minimise deflection of the drill rods, prevent damage to the surrounding utilities and to control drilling-mud returns.

For the 8in-diameter steel product pipe, the minimum acceptable design radius was established at 800ft, and the final entry and exit angles were 12.9° and 9.9°, respectively.

Maximum HDD borehole depth was approximately 55ft below road grade. Settlement and deflection monitoring points were installed in advance of work on critical buildings, existing below-grade utilities and on sidewalks along the route.

On the third day of drilling, the contractor encountered an ►

"The water pocket 'backflushed' the borehole and flooded city streets with 15,000 gallons of water"

Lessons learned

This project succeeded primarily because of a co-operative relationship between the owner, designers, general contractor and specialist HDD contractor. Problems that occurred were addressed openly, with a shared objective of completing the project and minimising impacts to the neighbourhood. Key learning points for other urban HDD projects are as follows:

- Geophysics in an urban setting can be successfully deployed, but ambient and point-source ground vibrations (from industrial equipment, generators, subways, etc.) can be a problem due to interference. Consider performing seismic studies at night to reduce urban vibration effects and traffic disruption;
- To prevent misunderstandings, use direct and explicit language to describe the subsurface materials and geologic conditions. For this project, citing three primary strata with descriptive terms based on their seismic compressional velocities was an effective means of conveying subsurface information to the bidding contractors;
- In addition to geotechnical baseline documents that include test boring and geophysical data, the contractor must rely on his own experience, equipment choices, personnel capabilities and the project limitations in considering HDD work;
- A qualified contractor is critical in a difficult, complex project. The experienced HDD contractor was able to overcome the challenges;
- In urban settings, a robust subsurface utility engineering (SUE) utility markout and utility definition programme ('potholing') may not identify all critical utilities along the route. Establish a contingency plan to address unmapped, abandoned or damaged services, including an on-call, bonded utility repair service. Include contingency monies for utility repairs in the budget;
- Pipe stringing and assembly in the city will demand creative solutions, as unbroken laydown corridors are not guaranteed. Street closures, pipe hanging and intermittent halts during pullback can be expected;
- If possible, pipe fabrication and testing should be completed before HDD begins or additional float time should be considered. The contractor should be prepared to construct adequate shelters for curing of the pipe joint coating in inclement weather to prevent delays;
- To minimise interference to the general public, consider night-time pullbacks and no matter how much planning is completed ahead of time, be prepared to deal with unknown issues during construction and be able to adapt quickly.

unanticipated 'pocket' of perched groundwater while pilot drilling. The water pocket 'backflushed' the borehole and flooded city streets with 15,000 gallons (56,781 litres) of water.

Once the team determined that the water was not potable (e.g., not from a broken utility) the pocket was interpreted as a lens of water perched on the harder (less-permeable) rock surface. Mears collected the backflushed diluted drill mud, shuttled the excess mud from HDD entry end to exit end, and then reconditioned it for reuse. This improvised approach 'recycled' the mud rather than disposing of it.

Street closures were necessary in the immediate work area. One lane of Auburn Avenue was kept open during the drilling and pipe-pullback process, and

ingress/egress from two parking garages adjacent to the west-end work zone were maintained during the day. Traffic-control personnel were stationed at several key cross streets to manage pedestrian and vehicle traffic.

For pipe fabrication, Georgia Power leased a series of vacant municipal lots and unused community gardens to assemble the product pipe into three separate strings. Pipe welding during pullback required close traffic co-ordination and temporary road closures, as the assembled pipe extended diagonally across the vacant lots, over a wall, across several roads, beneath the Interstate I-75/I-85 overpass and into the east-end drill hole.

During pullback, a large contingent of contract police officers assisted with directing traffic and pedestrians during the night hours. The three pipe strings had to be welded, coated, cured and certified during pullback, and cold temperatures delayed curing of the weld coatings. Pullback took over 27 hours.

The final 200ft of the borehole annulus on the east end was pressure-grouted, effectively sealing the downhill end of the drill hole from potentially draining the water 'pocket'.

The utility relocation project was essential to building the Atlanta Streetcar system

"Pipe welding during pullback required close traffic co-ordination and temporary road closures"

This article was written by Bradford Miller, P.G., Haley & Aldrich; Mark Smith, P.E., Southern Company/Georgia Power; and Dennis Doherty, P.E., Haley & Aldrich