FEATURE ARTICLE

Tunneling success at Denver's Platte to Park Hill project is a team effort

The city of Denver, CO has experienced extreme growth in the past decade, with the population of the city topping more than 700,000 people in 2018. The current storm water drainage system was put in place in the early 1900s and has not been able to keep up with the growth of the city.

When it rains north and east of the city, the runoff goes toward the South Platte River. With the dense population and sometimes severe thunderstorms in the summer, the city has experienced significant flooding that not only endangers lives of residents, but some of the storms have caused millions of dollars of property damage.

The Platte to Park Hill Project is a $298-million near-term, four-phase solution to the flooding that includes the Globeville landing outfall; an open drainage project in the Cole neighborhood in north Denver; an area for temporary water detention and another temporary water detention in Park Hill.

The largest and most complex phase of the project is the Globeville landing outfall — a $70-million box culvert project that includes a pair of 157-m (515-ft) long, 243-cm (96-in.) diameter storm water tunnels that pass beneath a busy rail yard with 17 tracks for the Union Pacific Railroad (UPRR) and two Regional Transportation District (RTD) commuter rail tracks. The tunnels, which were installed parallel to a pair of existing 243-cm (96-in.) tunnels, were designed by Brierley & Associates as a client of Merrick & Company for the City & County of Denver and Bradshaw Construction constructed the one-pass tunnels.

From the start, it was evident that the tunneling portion of the project would be the most challenging because of the rail yards.

"It's a little bit more complicated because the railroads have such tight restrictions for settlement," said Rebecca Brock, Brierley's project manager. "We had a lot of meetings with Union Pacific and RTD to figure out what are prescribed versus tolerable settlements."

"The portion extending beyond the UPRR under the RTD rails was challenging, as RTD is new to tunnel installations under its tracks," said Lester Bradshaw, president of Bradshaw Construction. "The RTD tracks employed a unique foundation of continuous concrete with integral raised concrete ties on rubber bushings. Minimizing settlement to these tracks was a critical requirement.""

by William Gleason, Senior Editor

As if that wasn't enough of a challenge, there was also a buried pipe that was known to be in the path of the microtunneling machine. Ever since Dec. 6, 2013 the words "pipe" and "tunneling boring machine" in the same sentence have sparked fear in the minds of tunneling professionals. It was then that the largest tunnel boring machine in the world, Bertha, came to a halt on the SR-99 tunnel project in Seattle, WA. Initial reports were that a buried steel pipe jammed the machine, causing the delay and while the cause of that delay is still to be determined, what is known is that when Bertha stopped a two-year delay and hundreds of millions of dollars in extra costs followed.

"We knew there was the potential for a utility to be in the way, " said Ryan Crum, project manager for the City

The microtunneling boring machine is lowered to begin boring the first of two storm water tunnels in Denver, CO. Photos courtesy of Kyle Friedman, Brierley Associates.

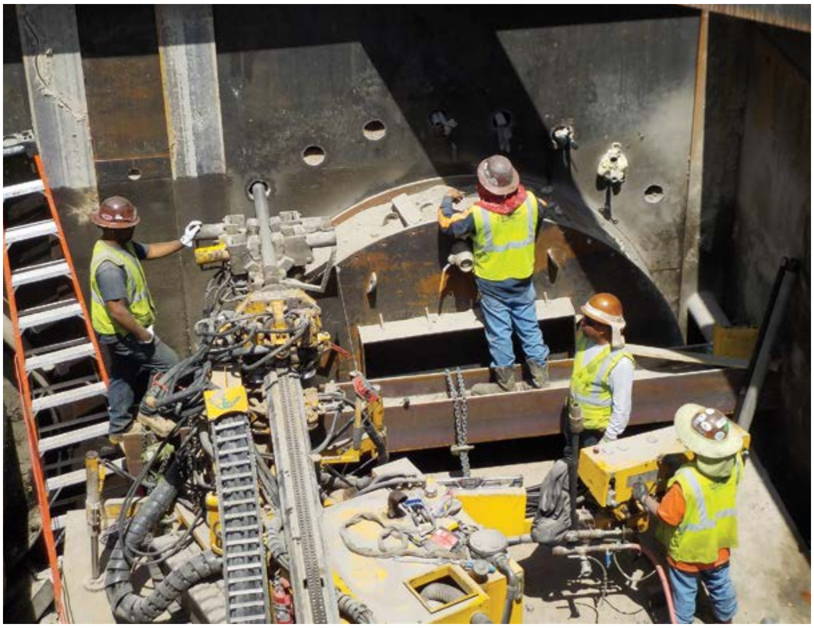
and County of Denver. "We did know that at one time there was a 175 cm (69 in.) reinforced concrete pipe somewhere near RTD's property but not exactly where it was or the condition of the pipe. We had heard that it was potentially crushed but we later found out that it was not crushed, and that it had been half-way removed and the bottom of the pipe was intact."

Potholling before tunneling began failed to find the pipe and the condition of the pipe was not known, nor was it known how much other debris might be in the path of the tunnel.

"We thought it might be small rebar and mesh that we could cut through and the machine did that, but the other worry, and what turned out to be a legitimate problem was when the machine hit the zone of crushed and intact concrete it was difficult to maintain the machine's slurry pressure, which, in turn, made it difficult to control the face," said Bill Zietlow, of Brierley Associates.

Bradshaw said the machine encountered the pipe when it was protruding a little more than 0.4 m (1.5 ft) into the crown of the first tunnel.

A grouting canopy was installed above the second tunnel to mitigate the dangers of debris that was encountered by the mictrotunnel boring machine.



"The microtunnel boring machine (MTBM) soft ground cutter wheel easily cut through the pipe on the first drive. However, the MTBM also encountered manmade debris — wire, steel, PVC, asphalt, wood, etc. in the sewer line trench in addition to the reinforced concrete pipe. This debris caused repeated blockages of the MTBM slurry system, which, in turn, caused inadvertent surface returns, ground heave, extraordinarily high jacking pressures and deflection of the MTBM beyond the specified tolerances," said Bradshaw. "But it did not prevent us from completing the south drive."

It did slow the drive as the machine was often stopped so that the slurry system could be cleared. Bradshaw said some of the steel debris and PVC pipe was the most difficult material to contend with.

After the encounter with the buried pipe, the team reassembled to plan the second drive. Based on where the pipe was encountered the team was certian that the second drive would be obstructed by the pipe.

Meanwhile, on the surface, the team kept a constant eye on the ground movement with extensive monitoring of the project using a system called Automated Total Station (AMTS).

"The system was used on the RTD tracks because of the restrictions for access," said Brock. "The system allowed for a higher frequency of survey intervals. The user end had a real-time website that any team member/owner could access to view the status of survey points at any time."

The first pass was completed close to the specificed parameters, but there was concern that the buried pipe would cause more problems on the second drive. While the machine was able to work through the debris, the slurry discharge was problematic and there was concern that the MTBM would encounter mixed ground that could lead to a loss of face pressure and, in turn, result in serious ground control issues. Working beneath the rail lines added extra pressure.

"We did not have the option (of a recovery pit) if the machine were to get stuck to retrieve the machine or do an open cut," said Crum.

Crum said the City and County of Denver, Kiewit, Bradshaw Construction and Brierley conducted a number of meetings and developed a host of contingency plans for the second pass of the tunnel.

Among the contingency plans were to have crews on standby to hand tunnel to the machine if necessary or to mud jack beneath the track to level the tracks. However, knowing that the pipe and other debris would be there, the team decided the best course of action would be to stablize the ground that the MTBM would encounter.

Grout canopy

The team from Kiewit, led by project manager Reid Korbelik, presented the plan that ultimately won out, which was to grout the concrete reinforced pipe debris and install a grouted pipe canopy over the north tunnel from the receiving shaft back to the RTD tracks that would provide ground support for the microtunneling machine.

Korbelik told *T&UC* that this plan was the best option based on cost, the amount of risk to adjacenet structures and utilities and to the crew doing the work.

"The canopy allowed for more structural stability to the earth beneath RTD, and the pipe solidification gave Bradshaw the best opportunity to tunnel through the pipe with consistent face resistance and minimal blockages," Korbelik said.

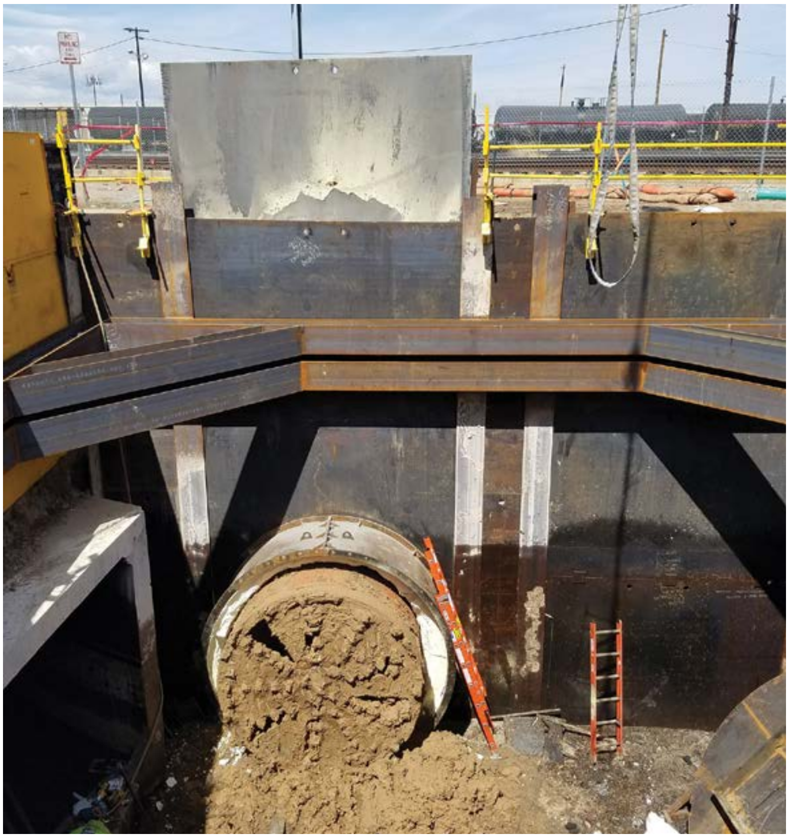
"The biggest challenge for grouting was the horizontal drilling that had to take place to develop the canopy structure," Korbelik said. "The drill rig could not get close enough to the proposed tunnel from the surface, so a small rig had to be flown into the receiving shaft with a crane, set on a temporary scaffold deck built up 1.2 m (4 ft) so the low-set machine could reach above the 2.4 m (96 in.) tunnel. It had to be restrained to a horizontal waler to keep the rig from pushing the scaffold deck over while pushing casing under the tracks. This all had to be done in the middle of a very large and active storm sewer corridor, because the receiving shaft split an existing 3 x 3 m (10 x 10 ft) box culvert that carries an immense amount of runoff for this area of Denver. Our timing and detailed planning were critical."

The MTBM did indeed encounter debris and other materials early on the second drive and the machine was able to work through that. For the next 122 m (400 ft), it was smooth mining until the pipe was encountered again, but thanks to the grouting work that had been done the machine was able to handle the challenge.

"The second microtunnel drive suffered blockages early from debris in the MTBM and slurry system left over from the first drive that could not be removed without major tear down of all the equipment and weeks of delay," Bradshaw said. "However within 15 m (50 ft) of mining, the blockages ceased and the second drive went extremely well. The MTBM went through the grouted pipe and into the shaft in a scant four hours compared to an agonizing three-day sojourn on the first drive."

"The grouting was so effective that combined with a special Bradshaw microtunneling technique that essentially no settlement of the RTD tracks occurred on the second drive," said Bradshaw.

A microtunnel boring machine breaks through as part of Denver's Platte to Park Hill Project. The 157-m (515-ft) storm water tunnel passed beneath 17 Union Pacific and two commuter rail lines.



"We have worked with a grout canopy before," said Zietlow of Brierley. "However, the loads are significantly higher than road traffic and the vibrations are much deeper, so that was a real challenge."

"The tunneling of the two drives was completed with no disruptions to either UPRR rail yard or RTD's commuter rail service," said Zietlow. "Overcoming the pipe obstruction was a team success led by Kiewit and the City and County of Denver along with team members Merrick and Brierley as designers and Bradshaw and Hayward Baker as subcontractors."■

Coming Events

2018 Cutting Edge
October 28-31 2018
Loews Atlanta Hotel
1065 Peachtree St. NW
Atlanta, GA

2019 Fox Conference
January 29, 2019
Graduate Center, City University of New York,
365 Fifth Ave., New York, NY 10016

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