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THE OFFICIAL PUBLICATION OF UCA OF SME WWW.TUCMAGAZINE.COM VOLUME 13 N0. 1 March 2019

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2019 George A. Fox Conference

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COVER STORY

In this issue — The McCook Main Tunnel and Reservoir Plan Mainstream Tunnel includes the world's largest tunnel gates and reservoir connection. The connection goes online as part of Chicago's tunnel and reservoir plan, page 10. The UCA of SME's Fox Conference, once again, sold out, page 26.

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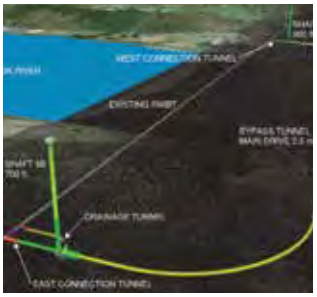

DEPARTMENTS

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CHAIRMAN'S COLUMN

Updates from the UCA executive committee

January found many of us in New York City to attend the annual George A. Fox Conference. This year's theme was "Water Tunnels: Past, Present & Future." Conference Chair Paul Madsen hosted another sellout crowd of 370. Attendees were treated to water tunnel history lessons from Boston and New York.

Following the Fox Conference, the UCA of SME Executive Committee held its annual winter meeting. Below is a summary of the many action items covered.

Individual membership in the UCA is strong, standing at 1,104 at years end. 2018 included a successful focus on growing the corporate and sustaining membership, yielding a 14 percent increase in these membership groups for a total of 294.

Planning for the Legislative Fly-In Program is well under way, with 10 UCA Executive Committee members joining members of the American Society of Civil Engineers (ASCE) in the annual program. This is an opportunity to meet with congressional leaders to address civil engineering matters as well as those specific to underground construction. This is our opportunity to promote our industry and recruit the political champions necessary to move many major projects forward. The 2019 event is scheduled for March 12-14. For the UCA, this will be a pilot program to determine if there is value in our participation for both the UCA and ASCE.

ITA Executive Director Olivier Vion attended the meeting for discussion surrounding November's joint Cutting Edge Conference/ITA Tunneling Awards in Miami, FL. Mark your calendars for this Nov. 18-20, 2019 international event.

While Vion was in the room, the UCA of SME board presented him with the official letter nominating Randy Essex for the position of vice president of the Executive Council of the International Tunneling and Underground Space Association (ITA). Essex's dedication to the ITA began in the 1980s as a member of the Contractual Practices Working Group. He has served as the U.S. representative to the ITA for five years prior to being elected to the executive council in April 2017. We look forward to Essex being elected vice president during the 2019 World Tunneling Congress in May.

We have four members of the UCA Executive Committee with terms ending June 30, 2019. Executive council members are eligible to serve no more than two consecutive four-year terms. A call for nominations was issued in October of last year to all UCA members. In response, we received 18 nominations for consideration. Based on demonstrated interest and past participation within the UCA, the following individuals have been elected to the executive committee.

- Tony O'Donnell (second term)
- Red Robinson (second term)
- Matt Preedy (second term)
- Jon Klug (first term)

Additionally, due to a vacancy caused by a resignation, the committee has elected Mike Bruen to fill the remainder of the vacated position through June 2022. Lastly, the committee has elected Mike Rispin as vice chair for the term June 2019 to July 2021. Per our bylaws, Rispin will then succeed Bob Goodfellow as chair.

Len Worden is completing his second term on the executive committee and is currently not eligible for re-election. We want to thank Len for his many years of dedication not only to the UCA, but to our business in general. We know that he will continue to be a champion of the industry and expect to see him back on the executive committee soon.

Mike Roach,
UCA of SME Chairman

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New York plans to move forward with plans to repair Canarsie tunnel to avoid long delay

A plan to repair, rather than completely rebuild, the Canarsie tunnel, also known as the L-train tunnel between Manhattan and Brooklyn, NY, that was damaged by Hurricane Sandy was announced by New York Gov. Andrew Cuomo as a way to avoid a planned 15-month shut down.

Cuomo framed the repair plans as a major technological breakthrough and told reporters that the proposed methods have been used successfully in Europe.

Cuomo made the surprise announcement just weeks after convening a panel of top engineering experts to take another look at the L-train tunnel beneath the East River to see if there was a way to fix flood damage from 2012's Hurricane Sandy without doing as much demolition and disrupting so many lives.

"This was an outside-the-box, creative solution," said Cuomo, at a news conference announcing the new plan. The *Associated Press* reported that he was flanked by engineering experts from Columbia and Cornell universities who dreamed up the proposal.

"You have to be willing to think outside the box or break the box," he said.

The announcement came after years of planning for the upheaval expected to be caused by the tunnel's closure, which was supposed to happen in April.

Brooklynites had already begun rearranging their lives for the expected "L-pocalypse," with some changing jobs or apartments to avoid the looming commuting snarls.

The original plan, adopted by the Metropolitan Transportation Authority after lengthy public debate, had called for a complete shutdown of a portion of the L line for 15 months while workers repaired damage from Sandy, when salty, corrosive water flooded 11 km (7 miles) of the tube.

The plan called for replacing old electrical equipment by removing a damaged concrete benchwall that lines the tunnel and encases power cables. The cables would then have been replaced and the wall rebuilt, in a labor-intensive process.

The new plan calls for installing cables on racks along the inside of the tunnels and leaving the old cables where they are. The old concrete benchwall would stay too, encased in a protective fiber-reinforced polymer, where

(Continued on page 8)

DC Water tunnel saves Anacostia River from 4.5 billion gallons of sewage overflow

The first 11-km (7-mile) segment of the Anacostia River Tunnel system was opened in March by DC Water and the tunnel has already helped save the Anacostia River from 17 billion L (4.5 billion gal) of sewage overflow in 2018, DC Water announced.

This massive structure stores combined sewage during rain events, keeping sewage from overflowing to the river. From March through Dec. 31, the tunnel prevented 17.3 billion L (4.57 billion gal) of sewage, and nearly 816 t (900 st) of trash, solids and debris, from entering the Anacostia.

For Washington, D.C., the prevented sewage comes as the city had its wettest year on record in 2018 with 168 cm (66.28 in.) of rain — nearly 12.5 cm (4.95 in.) more than the 155.77 cm (61.33 in.) total in 1889.

"This year was the ultimate test for the Clean Rivers Project tunnel system, DC Water chief executive officer and president David L. Gadis said in a statement. "In the rainiest year on record, the tunnel, along with green infrastructure, beat all projections for cleaning the river. The improved health of this waterway is bringing a renaissance to the waterfront, from housing, retail and sports venues, to recreational and environmental opportunities."

Now, instead of flowing into the Anacostia, the combined stormwater and sewage is captured and conveyed to the Blue Plains Advanced Wastewater Treatment Plant for treatment prior to discharge to the Potomac River. According to DC Water, the system exceeded expectations by achieving an 89 percent capture rate – besting the originally projected 80 percent in an average rainfall year.

The first portion of the Anacostia Tunnel provides about 378 million L (100 million gal) of storage and includes a 851 million L/d (225 million gal/day) Wet Weather Treatment Facility at Blue Plains. The next portion of the Anacostia River Tunnel system, the Northeast Boundary Tunnel, is under construction now and will add approximately 340 million L (90 million gal) of storage when it is placed into service in 2023. The Northeast Boundary Tunnel also reduces the chance of flooding in Northeast Washington, D.C. neighborhoods that have struggled with flooding issues for over 100 years.

In June, the Anacostia River received its first passing grade on

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Proposed tunnel to Chicago's O'Hare airport moving through environmental process

The tunnel to connect O'Hare airport to downtown Chicago, IL, proposed by Elon Musk and the Boring Co. is now midway through an environmental assessment, the *Chicago Tribune* reported.

Tom Budescu, managing director of finance at the Chicago Infrastructure Trust, the organization charged with negotiating the contract on behalf of the city, made the announcement about the transit tunnel in January. The Boring Co. was selected for the job this summer, an announcement that came with much fanfare, including a joint press conference with Musk and Mayor Rahm Emanuel. After the assessment is completed, the tunneling project will go to Chicago's City Council for review.

"We're feeling very confident that the project agreement is getting to the point of refinement," Budescu said at an Infrastructure Trust meeting. "We're getting pretty far along in that process." He said that Boring Co. was working with federal and local officials, including the Federal Highway Administration and the Chicago Department of Transportation, on the environmental review mandated by U.S. law. Because the tunnel is likely to go under an interstate roadway, the Federal Highway Administration is overseeing the review.

The project advanced through the early stages of the environmental review process quickly, but Musk and his company have yet to get any of several proposed tunneling initiatives beyond the concept stage and into commercial service.

The *Chicago Tribune* reported that the progression may also be a sign of Emanuel's determination to advance the project before he leaves office this coming May. Three months after he announced that Chicago had selected the Boring Co. to build the tunnel, Emanuel said he wouldn't run for a third term as mayor, casting doubts on the future of the express service to O'Hare, which has been under discussion for years.

The proposed venture would whisk Chicago passengers from the city's downtown Loop district to the airport in about 12 minutes using Boring Co.'s loop technology: wheeled carriages the company calls autonomous electric skates. The skates would run at up to 240 km/h (150 mph) in dedicated tunnels.

It isn't the only Boring Co. project undergoing environmental assessment. A project to build a tunnel connecting Baltimore to Washington, D.C. is quietly moving ahead, with Boring Co. staff and the Maryland Department of Transportation currently working on an environmental assessment, a spokesman for the department told *Bloomberg*.

Meanwhile, although a test tunnel on Los Angeles's west side was scrapped last month, the Boring Co. plans to open a 1.6-km (1-mile) long test tunnel in Hawthorne, CA, near the headquarters of Musk's Space Exploration Technologies Corp. rocket company. A delegation from Chicago is expected to attend the opening next week.

The Chicago plan doesn't quite match the vision Musk laid out in a 2013 white paper on what he christened hyperloop, a technology that would run at 1,223 km/h (760 mph), about triple the speed of any high-speed train currently operating. In a June press conference, Musk said the hyperloop concept would work for longer distances between cities, whereas shorter distances such as the 27-km (17 miles) between downtown Chicago and the airport are better suited for the scaled-down loop technology. A loop system could one day connect to a broader hyperloop system, he said.

Boring Co. has said the Chicago project will cost $1 billion, though experts have said similar projects typically cost much more. The company said the price for riders will be about half that of an Uber or taxi, which is currently about $40 per fare. ■

Seattle's SR-99 tunnel opens to the public

Seattle, WA celebrated the long-awaited opening of the SR-99 project during the first weekend of February, as more than 100,000 people walked, ran and biked through the tunnel. This was followed on Feb. 4 as the tunnel that faced lengthy delays and cost overruns opened to traffic.

The $3.3 billion, 3.2-km (2-mile) long tunnel will replace the earthquake-damaged Alaskan Way Viaduct, which the city plans to tear down this month to make way for a new and improved waterfront area and eight acres of new public parks, according to *The Washington Post*.

With an updated waterfront and better access to that area's popular attractions, including the Seattle Aquarium, officials hope the tunnel will boost Seattle's tourism industry and bring the city's infrastructure into the 21st century.

The tunnel's completion has been much-anticipated after a decade of planning and work, including a two-year construction delay due to issues with Seattle's drilling machine, Bertha. ■

Amtrak looks to alternative repair method for tunnels damaged by Hurricane Sandy

Officials at Amtrak said that they would also consider the tunnel repair technology that New York Mayor Andrew Cuomo has proposed to use on the Canarsie tunnel that was damaged by Hurricane Sandy in 2013 (see page 4).

Engineers from Amtrak will study Cuomo's plan to determine if it would be an appropriate solution for repairs on its tunnel between Manhattan and Queens that was also damaged by flooding from the storm.

The *New York Daily News* reported that Cuomo's plan involves a different way of repairing the cables that would keep the tunnel's capabilities intact. They have so far called the idea a "common-sense solution" and one that would create a more tolerable experience for passengers.

"It is important for us to do a thorough vetting so that we can determine now at this stage whether it's a methodology that we could use," Amtrak chairman Anthony Coscia told the *Daily News*.

Amtrak has plans to demolish the insides of two East River tunnels, both damaged by Hurricane Sandy in 2012, and rebuild them in a fashion that is similar to what was originally planned for the L train line.

While the multi-billion dollar Gateway tunnel project to repair tunnels beneath the Hudson River that connect Penn Station to New Jersey is a top priority, Amtrak officials aren't confident that Cuomo's approach could work in this case, since there are structural issues to the Hudson River tunnels that existed before Hurricane Sandy. Though flooding was worse in the East River tunnels, the problems within the Hudson River tunnels are more pressing.

Coscia says that once experts determine if Cuomo's idea is workable for Amtrak, the company will act quickly to get the project going. However, he's unsure how long it will take to vet the proposed methods. ■

Ambitious transportation plan in Norway would include floating tunnels

An ambitious $40 billion plan in Norway could transform transportation along the country's west coast and include a series of tunnels that could include the world's longest rock tunnel as well as a world's first floating tunnel.

To travel the west coast of Norway from Kristiansand to Trondheim is a 1,100-km (684-mile) journey that crosses seven fjords by ferry and takes about 21 hours. The plan being considered, Ferry-Free E39, would cut that travel time in half with a series of bridges and tunnels across the fjords.

One planned tunnel will set a world record for a rock tunnel drilled under the seabed of a fjord. It will be 391-m (1,286-ft) deep and 27-km (17-miles) long.

"Route E39 is a key route for Norway," said Kjersti Kvalheim Dunham, a project manager overseeing the revamping of the E39 route. "Improved transport will improve welfare for the local population, open up to more exports and increase tourism."

In fact, she said, "the tunnels may become attractions," like a "new Eiffel Tower on and under the water."

Creating a pleasing driving environment is just part of the plan for another unique tunnel along the future E39. At 1,300-m (4,265-ft) deep, the largest in Norway, Sognefjord is too deep to dig a tunnel beneath the sea bottom.

Instead, the plan calls for something the world has never seen before: a submerged floating tunnel.

The tunnel would be anchored in the bedrock on either side of the fjord, submerged about 30-m (98-ft) below the surface of the water, low enough for the biggest ships to pass safely over, and with plenty of space underneath for submarines to come and go.

In addition to staying clear of water traffic, the depth of the tunnel assures smooth driving.

"Wind, waves and currents have hardly any influence there," Arianna Minoretti, a chief engineer at Norway's Public Roads Administration, told *ABC News*.

She said 50 international experts "are doing detailed simulations and detailed measurements of wind speed, current, undersea landslides, bedrock geology, etc." to make sure the plans, as well as the tunnel, is rooted in "the real-world environment."

The two concrete tubes of the tunnel — one for traffic headed in each direction — will be firmly fixed in position and attached to floating pontoons, spaced 250 m (820 ft) apart to allow sea vessels to pass through.

This ambitious line of bridges and tunnels for the new Highway E39 is part of an even bigger network.

"Norway already has got 1,170 tunnels, 37 of which go under water," explained Kvalheim Dunham. "Norwegians are quite used to going under water in tunnels."

The new highway won't be ready anytime soon. To date, 10 percent of the project has been completed.

By 2025, 33 percent of the project is expected to be completed. The entire route won't be fully finished until 2050, Kvalheim Dunheim said. ■

New York: Repair method has been used in Europe

(Continued from page 4)

necessary, or patched.

"This is technology that is known to the MTA," Michael Horodniceanu said.

Horodniceanu was in charge of all major MTA projects from 2008 to 2017 as president of MTA Capital Construction.

The technology he referenced is a type of reinforced fiber he said has been used on tunnel walls. Under Cuomo's plan, that fiber would be used to patch the concrete benchwalls inside the L-train tunnel that were damaged by Hurricane Sandy floodwaters. The electrical cables inside the benchwall would be abandoned and new fireproofed cables mounted along the tunnel wall. The MTA's previous plan called for completely demolishing and replacing the benchwall, which Horodniceanu said would have given the structure a longer life cycle.

"Clearly, rebuilding it totally, it will enhance the life, more than if you just fix it," Horodniceanu said.

Not having to take out and replace the old wall cuts down on cost and time, officials said. And the new plan could be accomplished with night and weekend work instead of a shutdown.

MTA Acting Chairman Fernando Ferrer called the new plan "an innovative and more efficient approach" and said the agency, which operates in the city and its suburbs but is controlled by the governor, would adopt it in full. ■

Herrenknecht nominated for innovation award

E-Power Pipe is a trenchless method for the economic and environmentally friendly installation of underground cables. The new development from Herrenknecht was nominated for the bauma Innovation Award 2019 in the Machine category.

Trenchless technology offers significant advantages over the conventional open-cut method. The innovative procedure closes a technical gap because it allows small- diameter drives with 10- times greater lengths, shallower depths as well as high precision and speed.

With E-Power Pipe, Herrenknecht has developed a new method to quickly and securely install small-diameter cable protection pipes underground over long distances of more than a kilometer. The innovative method has purposefully modified and further developed proven drilling technologies so that in the future, underground cables can be installed trenchlessly and close to the surface at a depth of between 2- and 4 m (6 and 12 ft) with minimal intervention in the landscape.

The heart of the system is the fully remote controlled tunnel boring machine AVNS350XB, which has an excavation diameter of 505 mm (20 in.) and is designed for drive lengths of more than 1,000 m (3,280 ft). The machine can keep to the planned alignment with high precision and thus cross safely under existing infrastructure such as pipelines, roads, railways or smaller bodies of water. Individual boreholes can be placed a small distance apart of only 1-2 m (3-6 ft), so several lines can be installed in parallel.

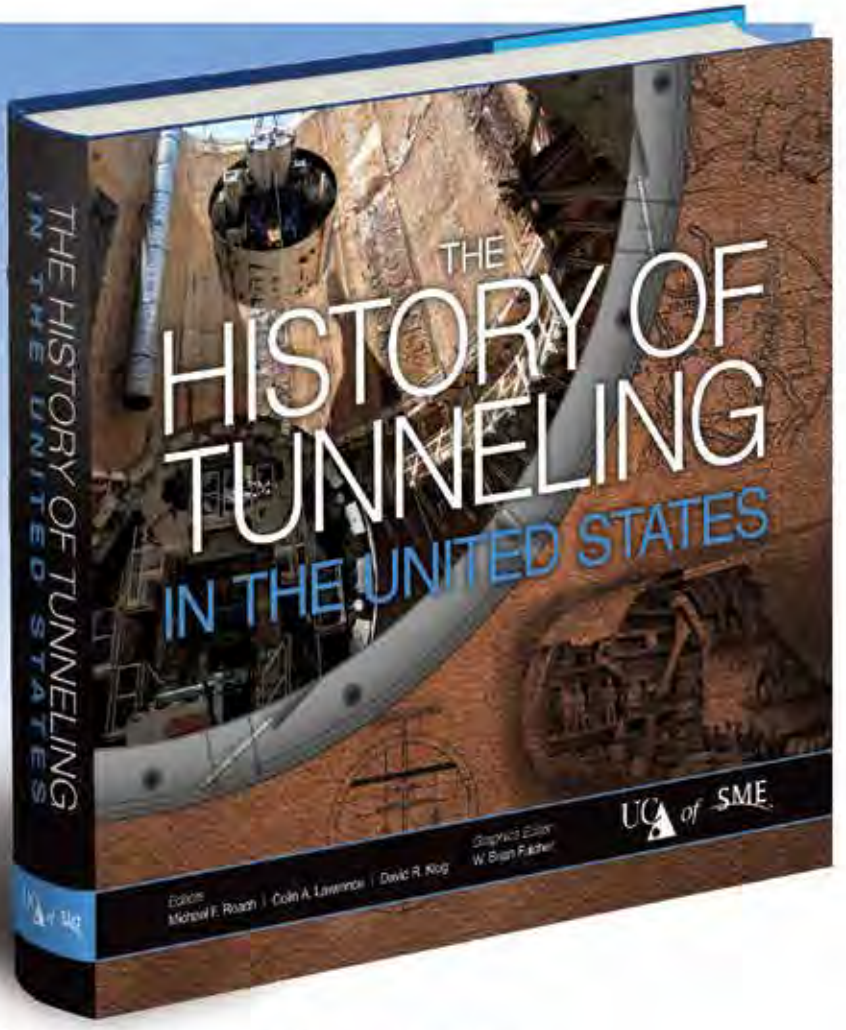
The tunneling machine is equipped with a jet pump and an integrated hydraulic power unit. With conventional methods, space restrictions limited muck removal over longer sections and as a result also limited the drive lengths possible. Through the use of the jet pump for transporting the muck, up to 10 times longer tunneling distances can be realized at high speeds in the small-diameter range.

At the starting point, a newly developed push and pull unit is installed, and its thrust is used to push the jacking pipes and the TBM along the specified route in the direction of the target point. The borehole remains securely supported by the machine and the jacking pipes the entire time. After breakthrough at the target point, the TBM is separated from the jacking pipes. Subsequently, the prefabricated cable protection pipe is connected to the jacking pipes still located in the borehole and pulled back and thus into the borehole by the push and pull unit in the launch shaft at the other end. After installation of the protection pipe, the E-Power Pipe mission is complete. Final insertion of the underground cables is carried out by appropriately specialized companies.

The method innovation involved the development of new, extended jacking pipes that allow a much more continuous advance. Herrenknecht developed an appropriate push and pull unit with a 10 m (33 ft) stroke and a push and pull force of 350 t (385 st) specifically for these jacking pipes. The technology is based on a rack-and-pinion guide, powered by electric motors. As a result, the innovative concept ensures higher installation performance and greater acceptance thanks to lower noise emissions.

The efficiency of E-Power Pipe has already been successfully demonstrated in pilot projects. Daily best performances of 184 m (603 ft) were achieved of during tunneling and 266 m (872 ft) when the protective pipe was pulled in. The development of the method received funding from the Federal Ministry of Economics and Energy (BMWi research project IBoTec) and was carried out by Herrenknecht in cooperation with Amprion GmbH and with RWTH Aachen. ■

New Book Chronicles 200 Years of Tunneling in the United States



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Klug, Lawrence, Roach, Fulcher

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UC of SME

FEATURE ARTICLE

World's largest tunnel gates and reservoir connection go online as part of Chicago's Tunnel and Reservoir Plan

Miguel Sanchez, Faruk Oksuz, Dave Schiemann and Patrick Jensen

Miguel Sanchez, member UCA of SME, and **Faruk Oksuz** are senior engineering manager and vice president, Black & Veatch, **Dave Schiemann** is civil engineer, U.S. Army Corps of Engineers, Chicago District and **Patrick Jensen** is civil engineer, Metropolitan Water Reclamation District of Greater Chicago email sanchezma@bv.com.

The McCook Main Tunnel connects Chicago's Tunnel and Reservoir Plan (TARP) Mainstream Tunnel to the McCook Reservoir. The tunnel system consists of a 10 m (33 ft) finished diameter and 490-m (1,600-ft) long hard-rock tunnel constructed from a 27.5-m (90-ft) diameter and 92 m (300 ft) deep main gate shaft. The gate shaft houses six high-head 4.4 x 9 m (14.5 x 29.5 ft) wheel gates installed in the bifurcated and steel-lined section of the tunnel. The tunnel also includes portal and energy dissipation structures as it daylights into the reservoir.

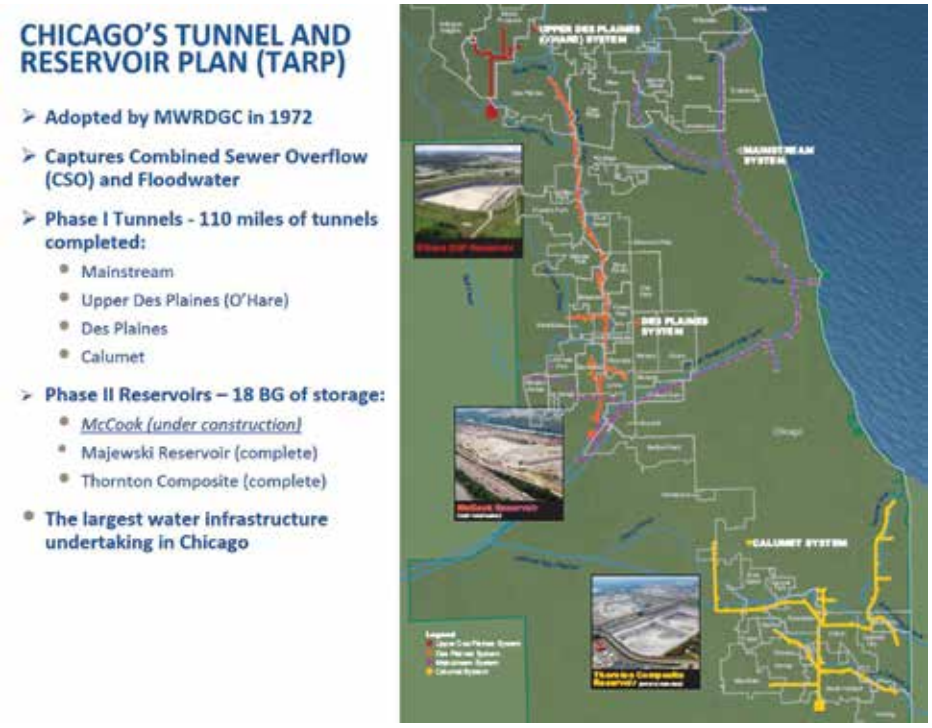
Construction of the McCook Main Tunnel in live flow conditions was a challenging task for the McCook Main Tunnel Project participants, the project owner U.S. Army Corps of Engineers (USACE), local sponsor Metropolitan Water Reclamation District (MWRD) of Greater Chicago, designer Black & Veatch and contractor Kiewit Infrastructure Co. (Kiewit). Once completed in two stages in 2017 and 2029, the McCook Reservoir will hold 38 billion L (10 billion gal) of combined sewer overflows (CSO) and flood waters from the city of Chicago and 36 surrounding communities in Cook County, IL.

The construction of the tunnel system was divided into two contracts. The first contract for the gate and construction access shaft was completed in August 2011. The second contract included tunnel excavation and concrete and steel lining that was completed in September 2014; installation of gates and hydraulic cylinders that was completed in June 2017; and the last major construction activity was the removal of a temporary concrete plug (bulkhead) and lining that tunnel section to bring the overall tunnel and gates system online before Dec. 31, 2017.

This article focuses on the installation, testing and commissioning of the high head wheel gates. Live tunnel connection details to TARP Mainstream Tunnel were addressed in a previous paper submitted at the World Tunneling Conference in 2016.

FIG. 1

Chicago tunnel and reservoir plan and McCook Reservoir.



Chicago TARP System

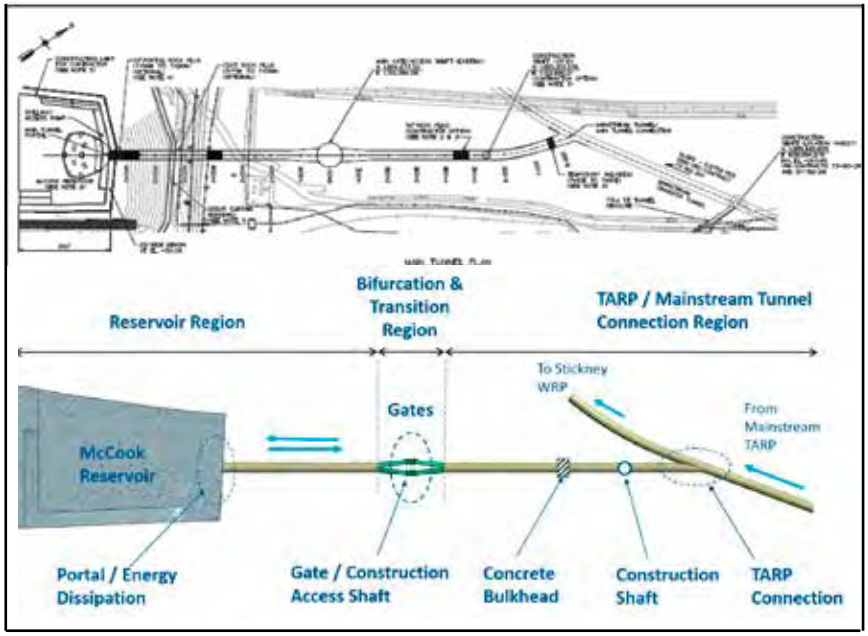
The MWRD has been addressing CSOs and flooding

in Chicago since the late 1960s and formally adopted the Tunnel and Reservoir Plan in 1972 to protect the region's most precious drinking water supply, Lake Michigan. Phase I of TARP, which included construction of 175 km (109 miles) of deep storage and conveyance tunnels with diameters up to 10 m (33 ft), was completed in 2006. In addition to the protection of Lake Michigan from CSO discharges, Phase I resulted in substantial improvements in surface water quality as well as the quality of life for lake and riverfront communities in Chicago. Water quality improvements and flooding mitigation will be further enhanced as Phase II reservoirs are placed in service, including the three, large reservoir systems, McCook, Thornton and Majewski, as shown in Fig. 1.

The McCook Reservoir is the largest reservoir in the TARP system. Once completed, this $1.031 billion reservoir facility will receive 38 billion L (10 billion gal) of CSO and floodwater via the McCook Main Tunnel which connects the TARP Mainstream Tunnel to the McCook Reservoir and from the Distribution and Des Plaines Inflow tunnels which will bring flow from the Des Plaines Tunnel of TARP.

FIG.2

McCook Main Tunnel layout and components.



McCook Main Tunnel layout

McCook Main Tunnel daylights into the McCook Reservoir at the northeast edge and extends east toward the existing Mainstream Tunnel (Fig. 2). The tunnel was excavated using sequential drill-and-blast and lined with concrete and steel in sections for long-term stability and to minimize infiltration and exfiltration.

The tunnel was excavated in its entirety in bedrock, consisting of massive, relatively homogenous Silurian and late Ordovician dolomites. These rocks form a relatively uniform 100+ m (330+ ft) thick sequence across the site and incorporate the Racine Formation, Sugar Run Formation, Joliet Formation, Kankakee Formation, Elwood Formation and Wilhelmi Formation of Silurian age. The tunnel is located in the Kankakee and Elwood formations.

The McCook Main Tunnel system has the following key components:

1. Main Tunnel Section: Approximately 490 m (1,600 ft) long, 10-m (33-ft) inside diameter, hard-rock tunnel, bifurcated into two tunnels for 88 m (290 ft) through the gate shaft section.
2. Main Gate/Access Shaft: 27-m (88-ft) diameter, 90-m (295-ft) deep circular shaft located near the midpoint of the Main Tunnel and houses the bifurcated tunnel section. This shaft was used for construction of the tunnel and houses the high head wheel gates for controlling flow between TARP Mainstream Tunnel and McCook Reservoir.
3. Construction Shaft (contractor option): A 7.6-m (25 ft) diameter and 87-m (285-ft) deep construction shaft was located at 91 m (300 ft) downstream or west of the Mainstream Tunnel connection. Kiewit elected to build this shaft to facilitate the live connection work. As the tunnel and gate shaft excavation and lining were completed, a temporary concrete bulkhead was installed to isolate the live connection section from the rest of gate and reservoir works to the east.
4. Gates: A total of six wheel gates operating under 100 m (330 ft) of water pressure head were installed in the Main Gate/Access shaft. Each gate measures 4.4 x 9 m (14.5 x 29.5 ft) with associated hydraulic cylinders, power units, and gate controls. Each bifurcated section of the Main Tunnel contains one main gate and two guard gates — one upstream and one downstream of the main gate. The gates, hydraulic cylinders and controls were manufactured under a separate contract and were provided to the contractor as government furnished items. The gates were designed by Black & Veatch and fabricated by Oregon Iron Works (now Vigor Works LLC).
5. MainTunnel/MainstreamTunnel connection: This is the connection section of the Main Tunnel to the existing, live 10-m (33-ft) diameter Mainstream Tunnel that remained in service throughout

FIG.3

Bifurcated and steel-lined gate section of McCook Main Tunnel.

construction. Removal of the temporary concrete bulkhead and lining of that tunnel section completed the connection.

6. Main Tunnel/McCook Reservoir connection: The Main Tunnel connection to the McCook Reservoir included portal excavation and stabilization work at the quarry highwall face and an energy dissipation structure. The portal was excavated from the reservoir side and supported with rock bolts, wire mesh and shotcrete.
7. Control building: A surface facility to house gate operating controls, hydraulic power units and provide limited storage.

The McCook Main Tunnel system design, construction, commissioning and operation were coordinated with the overall McCook Reservoir water control plan as well as the reservoir excavation, quarry highwalls stabilization, groundwater protection system construction, Distribution and Des Plaines Inflow Tunnel connections, and other reservoir features. Hydraulic structures were designed to withstand erosion or cavitation during reservoir filling and emptying cycles and to handle flows up to 850 m^3/s (30,000 cu ft/sec) and velocities approaching to 12 m/s (40 ft/sec).

Working with live tunnel flow conditions

The connection to the Mainstream Tunnel was challenging due to the limited amount of time available to access the connection area as the Mainstream Tunnel had to remain live or in service at all times. The connection is located near the downstream terminus of the Mainstream Tunnel which drains over the 65 km (40.5 miles) of tunnel network virtually encompassing the highly developed city of Chicago. MWRD operates the Mainstream Tunnel system and the Mainstream Pump Station to collect and pump out the CSOs and subsequently treats the flows through the Stickney Water Reclamation Plant. When it rains, the tunnel fills up rapidly, and there is also a constant

FIG.4

Upstream check dam (left) and bypass pipe and downstream check dam (right).

FIG.5

Bull nose at main tunnel (left) and mainstream tunnel connection and concreting of invert toward main tunnel.

base flow in the tunnel of about 113 to 150 million L/d (30 to 40 million gpd). Kiewit designed a base flow bypass system consisting of upstream and downstream steel check dams (partial bulkheads) with a 914-mm (36-in.) nominal diameter HDPE bypass pipe across the connection section of the Mainstream Tunnel (Fig. 4). The connection was lined with reinforced concrete starting with the invert, then walls and finally crown. The connection works in-progress were exposed to inundation multiple times where all personnel and equipment were evacuated from the area upon notice from MWRD operators or the weather service dispatcher. All installations were successfully completed despite multiple and complete flooding of work areas, and the tunnel and subsequent reinforcement and lining work (Fig. 5) were successfully completed by the end of 2016 as detailed in the referenced 2016 World Tunnel Congress paper.

Several lessons learned were valuable to the team as the Mainstream Tunnel was opened up for the first time after 35 years of service. The tunnel liner was in near perfect circular shape without any sign of damage, major cracking or water seepage. Despite being downstream, there was no sediment or grit accumulation observed, primarily due to high-velocity tunnel flows created with large dewatering pumps. It is noted however, there was significant grit accumulation in the Main Tunnel once the construction work was suspended over the spring and summer of 2015. The tunnel-liner concrete exhibited very high unconfined compressive strength, on the order of 83 MPA (12,000 psi) compared to initial placement specification of 28 MPA (4,000 psi), also known as the MWRD's RA mix. Visual inspection, field and laboratory testing of the concrete liner and verification of its existing condition allowed the designer to shorten the limits of excavation for connection by approximately 12 m (40 ft) at the downstream end.

High-head wheel gates

Six high-head, vertical-lift wheel gates were installed in the Main Tunnel to control the flow of CSOs and floodwater between the reservoir and Mainstream Tunnel. The gates are housed in the Main Gate/Access Shaft (MGAS) in the bifurcated section of the Main Tunnel (Fig. 6). Each bifurcation has one main gate and two guard gates — one upstream and one downstream of the main gate. All gates have an opening of 4.4 m x 9 m (14.5 ft x 29.5 ft). The main gates are the primary feature to control water flow and are designed to seal in both flow directions. The guard gates are designed to seal against hydrostatic head on one side only. The upstream guard gate holds back water on the Mainstream Tunnel side and the downstream guard gate holds back water on the reservoir side. The guard gates provide redundancy to the main gates and can also be used to isolate a main gate when needed for maintenance.

The gates are operated by a hydraulic operating system. Each gate is raised and lowered by a hydraulic cylinder that is mounted above the gate in a vertical position. The cylinders are actuated by two hydraulic power units (HPUs) at ground level in the control building near the MGAS.

Gate details

Each gate consists of three sections (leaves) that are pinned together to form the gate. There are four-pin connections between the lower and middle leaves and four-pin connections between the middle and upper leaves. The upper leaf is connected to the hydraulic cylinder by means of a single pin. Each leaf has four wheels, two on each side (Fig. 6). These wheels are the bearing portions of the gate when it is subjected to load.

The gates use neoprene seals to control the water. The seals along the sides and top of the gate are center bulb seals. The seals have a fluorocarbon coating on the bulb to reduce friction during gate operation. This coating will eventually wear away but does not compromise the sealing function of the seal. The seals on the main gates have a 0.95-cm (0.375-in.) preset deflection for flow toward the reservoir, and a 0.32-cm (0.125-in.) preset for flow in the reverse direction.

The seals on the guard gates have a 0.95-cm (0.375-

FIG.6

Gate leaf suspended from a crane (left) and gates in bifurcated section of main tunnel (right).

in.) preset. A pressure groove behind the seal is provided so hydrostatic pressure will force the bulb against the sealing surface. Holes in the seal bars allow pressure to build up in this groove. This groove also assists in lessening wear on the seals during gate movement when no differential pressure is present. A wedge seal is mounted at the bottom edge of the gate. The joint between the gate sections is sealed with flat natural rubber seals. All seals are split at the joint between gate sections to allow installation and removal of the gate in sections. The seals are detailed to allow a 0.16-cm (0.0625-in.) preset compression between the gate sections in order to minimize leakage at these joints.

Each leaf is a steel structure made up of welded horizontal plate girders that span from wheel to wheel. It is composed mostly of A572 grade 50 steel, with some portions that are 304L stainless steel. The gate is metallized with a zinc-aluminum coating to help protect it from corrosion. The metallized coating is sealed with a vinyl sealer. The gates are open on their loaded side (Mainstream Tunnel side for the main gates). This keeps the gate from being buoyant when submerged. Drain holes in the girder webs and in the gate bottom keep water from ponding on the girders as the water level goes down.

The wheels for each gate are 0.9-m (3-ft) in diameter and made form ASTM A705, UNS 13800, Condition H1025, 380 BHN stainless steel. They rotate about a fixed axle that is of the same material but tempered to a harder condition (430 BHN) so that wear will more likely occur in the wheel. The wheels are also softer than the wheel track plates so that wear will more likely occur in the wheel. The wheels are crowned with a 15-m (50-ft) radius so that they bear continuously on the wheel track plates even when the gate deflects under load. The wheels have a force fit bronze bushing that rolls on the greased interface between the bushing and the fixed axle.

The gate guides position each gate correctly and provide a seating and sealing surface for the gate. They consist of upper and lower guides. The upper guides are only used during gate installation and removal. They help to control gate motion in the upper part of the shaft. The upper guides are bolted to the concrete of the gate well walls. They consist of ASTM A36 angles that have been galvanized to provide a durable coating.

The lower guides are the primary traveling surfaces of the gate. The wheels of the gate run along wheel tracks. There is a front track and a back track. The distance between the tracks is slightly larger than the wheel, to keep the wheel from binding but also to reduce play in the gate itself. The wheel tracks run from the tunnel invert all the way to the cylinder support level. These wheel tracks are ASTM A693, UNS 13800, Condition H950, 430 BHN stainless steel. This is a harder material than the gate wheels so that damage occurs in the wheels rather than in the track. On the side of each guide is a roller track plate on which the guide roller contacts. These track plates are bolted to an ASTM A304L grade stainless steel that forms the guide slot. This also is the sealing surface of the slot. When seated, the gate presses up against the wheel track and compresses the seals against the sealing surface. The guides are anchored to the shaft concrete with embeds and rebar anchors cast into a 34 MPA (5,000-psi) second placement concrete.

The MGAS concrete consists of 34 MPA (5,000) psi reinforced concrete. This concrete anchors the steel liner and forms the sides of each of the six gate wells. It was designed to resist water pressure around the exterior of the shaft. Also, the walls between the gate wells were designed to resist the full height differential water pressure on them (i.e., one gate well full and the adjacent one empty).

The concrete was placed in sections. Between each vertical construction joint is a PVC waterstop system to resist leakage through the joint. The horizontal construction joints were prepared to allow for bonding between the concrete lifts and do not have a waterstop.

Each of the guard gate wells have large access spots,

FIG. 7

Hydraulic cylinder on a trailer (left) and a hydraulic power unit in control building (right).

enough to access the tunnel invert using a four-person crane basket. The main gate wells have access spots as well, but much smaller.

Hydraulic operating system details

The cylinders raise and lower the gates through the use of hydraulic pressure generated by the HPUs. Fluid pressures in the cylinder are monitored by two pressure transducers, one on the bore side of the piston near the top of the cylinder and one on the rod side of the piston near the bottom of the cylinder. The position of the cylinder rod is monitored by a position sensor. Each cylinder is made up of a shell a piston head, a rod, a clevis, supply and return piping, and a manifold with check valves. The bore diameter of the cylinder is approximately 1 m (3 ft), the rod diameter is approximately 0.3 m (1 ft) and the total stroke in the cylinder is approximately 9.5 m (31 ft) (Fig. 7). Each cylinder weighs approximately 65 kips and is capable of producing a jacking load of 2,100 kips. The cylinder rod is coated with a protective anti-corrosion metallic coating. The cylinder shell is coated with epoxy paint. The hydraulic fluid is carried by piping between the HPUs and cylinders.

The cylinders are actuated by two HPUs in the control building near the MGAS (Fig. 7). Each HPU typically controls three gates on each side of the bifurcated tunnel. Each HPU consists primarily of an internal reservoir, two pumps, a manifold, a PLC cabinet with screen and various internal instruments for the function of the HPU. There is a manual crossover between the HPUs to allow for redundancy in hydraulic operation.

Gate testing and operation

Several tests were conducted to check installation and operation of the gates, as follows:

- Gate leaf dry run test: While suspended from a crane, a gate leaf was slowly lowered and raised between the ground surface and tunnel invert to verify the proper alignment of the upper and lower gate guides and sill plate at the invert.
- Functional performance test: The fully installed gate system was tested to verify the operation of the HPUs, hydraulic cylinders, gates, and hydraulic piping under operating conditions.
- Intermediate (flat) seals air pressure test: The flat seals between the gate leafs were subjected to air pressure up to 1.2 MPA (175 psi) to verify performance of those seals prior to filling tunnel with water.
- Wet test: A 79-m (259-ft) column of water obtained from a canal was pumped into the gate shaft and tunnel on one side of a pair of guard gates and then one side of the main gates to test sealing of gates at full hydrostatic head conditions.

The normal condition for all gates is the raised position, allowing flow to move unimpeded between the reservoir and Mainstream Tunnel. The gate speed is approximately 0.3 m/min (1 ft/m), so it takes approximately 30 minutes for the gates to move from the open position to the closed position. When it is desired to isolate the reservoir from the Mainstream Tunnel, both of the main gates will be closed. In the event that the main gates do not close (or only one closes), the respective guard gates will be closed (upstream guard gates if the Mainstream Tunnel water level will be higher, downstream guard gates if the reservoir water level will be higher). The gates are designed to hold back large differentials of water pressure; however, the gates will typically be moved or operated when there is relatively equal water levels on both sides of the gate.

The motion of the gates is controlled by the HPUs in the control building at the ground surface. Generally, the gates are operated in pairs (i.e., both main gates move together, both upstream guard gates move together, both downstream guard gates move together). The gates

can be operated locally from the control building or remotely from the Stickney Water Reclamation Plant via SCADA.

Conclusion

Removal of the temporary concrete bulkhead and final stages of commissioning took place from late 2017 through the first quarter of 2018. Once the bulkhead was removed and construction of the remaining reservoir features was completed, including an inflow/outflow connection and aeration facilities, the reservoir became available to take water in December 2017..

The McCook Main Tunnel and Gates are one of a kind underground structures that are used for management of high-volume and high pressure flows in tunnels. Design, fabrication, storage, delivery, installation, and commissioning of tons of concrete and steel structures at depths up to 100 m (300 ft) were truly an engineering and construction feat for the many that worked on this project, and for those who will be benefiting from the water quality improvements and flooding mitigation for years to come. ■

Acknowledgments

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McCook Reservoir project update

FIG.8

McCook Reservoir Stage 1 before and after filling for the first time.

The first fill event of the McCook Reservoir Stage 1 occurred in February 2018, just two months after the reservoir and Main Tunnel and Gates came online.

The Stage 1 reservoir was filled with combined sewer overflow (CSO) and floodwater to its full 13.3 billion L (3.5 billion gal) capacity (Fig. 8), and no CSOs were discharged into Lake Michigan. This validated the project demonstrated the functionality of the Main Tunnel and Gates and realized the project benefits in terms of protecting Lake Michigan from raw sewage and minimizing local flooding. In its first year in service (as of Dec. 31, 2018) McCook Reservoir Stage 1 has captured approximately 103 billion L (27.2 billion gal) of CSO and floodwater. It has been filled multiple times, confirming the need for more storage that will be provided by Stage 2 of the reservoir.

Stage 2 of the reservoir is currently being mined and is projected to be completed by 2029 to increase the storage capacity of the McCook Reservoir to 38 billion L (10 billion gal) total.

This world-class project has been recognized with several industry awards, including the American Society of Civil Engineers (ASCE) IL Section 2018 Outstanding Civil Engineering Achievement Award in Mega Projects Category, Water Environment Federation (WEF) 2018 Project Excellence Award, and National Association of Clean Water Agencies (NACWA) 2019 National Environmental Achievement Award for operations and environmental performance. ■

FEATURE ARTICLE

High-capacity hoisting at Rondout West Branch Tunnel project

The existing Rondout West Branch Tunnel (RWBT) is part of the Delaware Aqueduct which has been in service since 1944 and accounts for more than 50 percent of New York City's water supply. In early 2015, the New York City Department of Environmental Protection contracted Kiewit-Shea Constructors, AJV (KSC) to construct the Rondout West Branch Bypass Tunnel project (Rondout) in order to mitigate the leakage of 132 million L/day (35 million gpd) of water from two areas of the existing tunnel; the Roseton and Wawarsing areas.

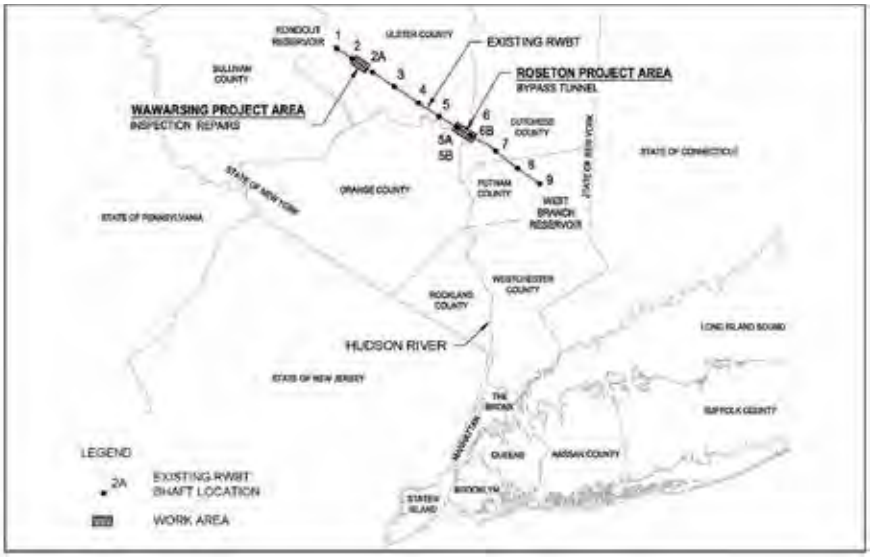
The scope of the Bypass Tunnel 2 project is separated into two distinct phases. Phase 1 consists of completing the shaft sinking to a depth of approximately 274 m (900 ft) at shaft 5B, 213 m (700 ft) at shaft 6B and the excavation of approximately 3,850 m (12,500 linear ft) of tunnel at a diameter of 6.6 m (21 ft 7 in). This phase also includes the installation of 2,804 m (9,200 linear ft) of 4.8 m (16 ft) diameter steel interliner pipe through the new bypass tunnel with cast-in–place concrete liner for a finished diameter of 4.2 m (14 ft). Access chambers at the top of shafts 5B and 6B will be constructed for access and housing of the mechanical and electrical equipment for supporting pumps and valves.

Included in phase 2 is the additional excavation from shafts 5B and 6B to the RWBT, and the drainage tunnel to remove ground water infiltration from RWBT. This work will be completed during a scheduled shutdown of the RWBT and will include approximately 31 m (100 ft) of excavation of the two connection tunnels. Additionally, construction of the permanent plugs within the RWBT will be undertaken. Figure 2 shows the layout of the work.

Access to the work through the deep shaft at site 5B was critical to the success of the project. The hoisting system needed to be multi-functional to handle the different types of construction from drill and shoot of the shaft, starter and tail tunnel, the assembly of the tunnel boring machine (TBM), the excavation of the TBM tunnel including the supply of the precast segmental liner, the grouting operations, the installation of the steel interliner pipe and the cast-in-place concrete as well as ingress and egress of personnel. The production of the TBM operations was critical to the schedule of the project. This required a quick cycle for muck haulage and supply of the precast segmental liner in order to keep pace with the excavation time of the TBM. For TBM assembly, components were limited to a maximum weight of 104 t (115 st) for a single lift. Various cranes were analyzed for hoisting, however, none would meet all of the citeria. Therefore, the project team selected a specialized hoisting system designed in house in conjunction with Timberland Equipment Ltd. that consisted of a total of 14 separate hoists and winches with a total of more than 2,833 kW (3,800 hp).

FIG. 1

Project location map.



Structural and mechanical design

The structural portion of the high capacity hoisting system at the Rondout project consisted of eight separate designed and fabricated major structural components weighing more than 567 t (625 st). These components

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FIG.2

Bypass tunnel alignment plan.

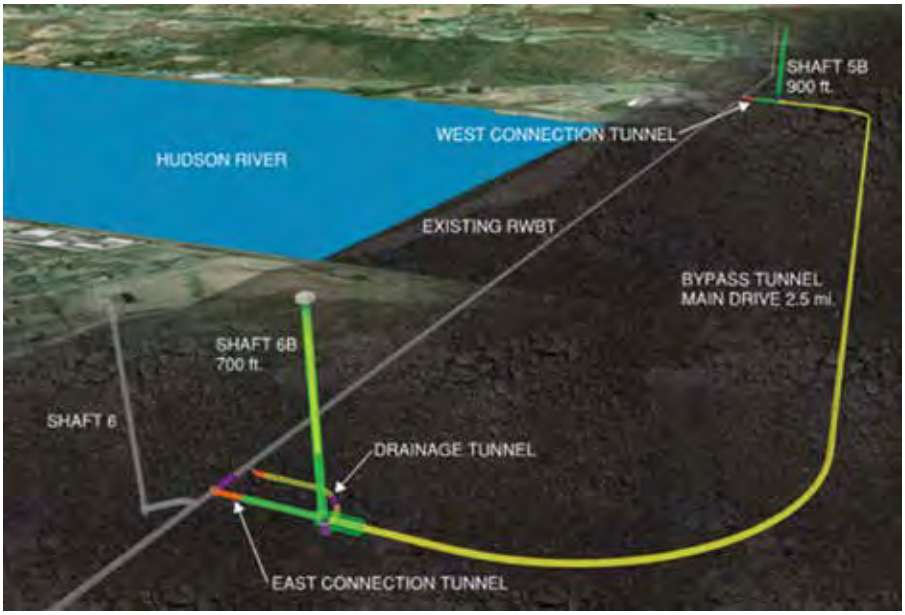
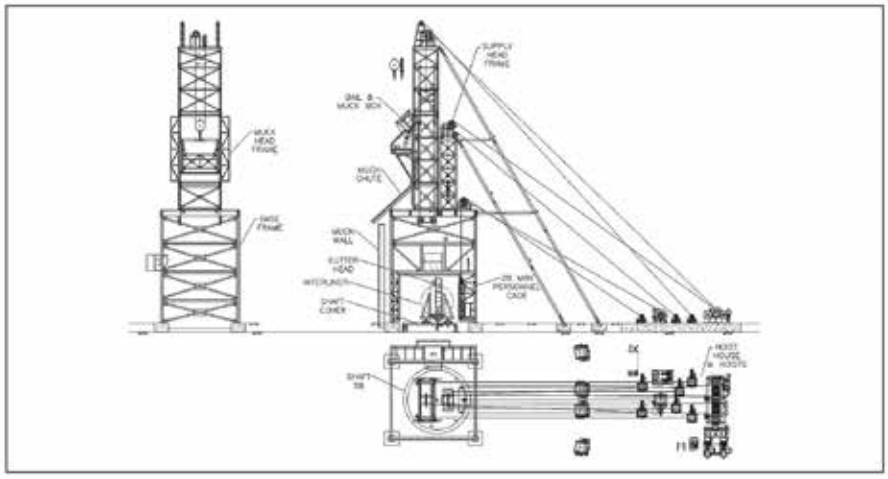


FIG.3

General layout of Rondout Shaft 5B headframe assembly.



were designed and supplied to access the 10-m (30-ft) diameter shaft to accommodate all of the previously mentioned operations throughout phase 1 of the project.

The main components consisted of:

1. A movable heavy-duty shaft cover.
2. Shaft runner beams with Hilman rollers.
3. The collar mounted base frame structure.
4. Muck head frame, dump scroll, chute and back wall.
5. Supply head frame.
6. Muck and supply back legs with erection frame.
7. Twenty-eight person personnel cage and access platform.
8. Muck car bails and muck cars.

Movable heavy-duty shaft cover. The movable shaft cover measures approximately 19 x 26 m (63 x 26 ft) and rolls on Hilman rollers in an east west direction powered by a 7-kW (10-hp), electric, Stanspec dual directional car puller. The dual directional puller utilizes 2.2 cm (0.875-in.) diameter wire rope with a 18,000-kg (40,000-lb) line pull at approximately 5 m/min (15 ftpm).

The overall length of the shaft cover is necessary because there are two 9-cm (36-in.) gage rail tracks installed on the cover to accommodate the roll-on of various TBM components that, along with carrier supports, will weigh approximately 127,000 kg (280,000 lbs). The cover is made up of three separate compartments, each with a very specific purpose.

The most eastern compartment is fixed and measures 10 m (30 ft) in length and only serves the purpose of supporting the dual rail tracks. The northwestern section measures 11 x 5.4 m (33 x 18 ft) and consists of five removable panels that will be removed during a mucking operation so that this section of the shaft will be opened for the raising and lowering of the muck bail and boxes.

The remaining area of the cover is designated as the supply door and measures 11 x 2.4 m (33 x 8 ft) in size. This section of the cover is supported by a series of four offset hinges so that the supply door may be rotated and moved to the north in such a way to completely open the supply area for the transport of tunnel rail, tunnel supplies and precast segmental liner. An electric Thern winch and an overhead sheave deck mounted on the north side of the shaft cover and base frame is used to open and close the hinged supply door as required.

A 2.4-m (8-ft) high safety fence is installed between the muck deck and the supply door so that hoisting of these two functions may take place simultaneously.

Shaft runner beams with Hilman Rollers. The shaft runner beams consist of two beams spliced together to

FIG.4

Base frame assembly.

form a continuous section, 30 m (100 ft) in length. Each 30-m (100-ft) long section is supported on four concrete footings founded on base rock foundations. There is a total of 10 Hilman rollers, each complete with Accu-Roll guides and a capacity of 50 t (55 st), that run on top of the two runner beams and, in turn, support the movable shaft cover as previously described. The 50 t (55 st) capacity of each Hilman roller is required to support the shaft cover and the point loading from the various TBM components during installation.

The collar-mounted base frame structure. The base frame structure is a large fabrication that measures 12 m (42 ft) wide by 12 m (39 ft) deep with a height of approximately 16 m (54 ft). The entire base frame is supported on four wide flange legs resting on concrete foundations on a solid rock base surrounding the shaft collar.

The required function of the base frame is to support the main muck and supply head frames, the personnel access platform, the muck dump scrolls and chute as well as provide an east and west opening that will allow the entrance of all tunnel supplies, all TBM components and the entrance of truck loaded interliner pipe that will measure 5 m (16 ft) in diameter by 12 m (40 ft) in length.

The east and west side openings in the base frame measure 9-m (30-ft) wide by 7-m (24-ft) high. The western portion of this 7-m (24-ft) high opening allows a rail mounted carrier to enter the interior of the base frame while supporting a 7-m (22-ft) diameter TBM cutter head.

FIG.5

Head frame assembly; supply frame, upper stair tower, upper muck frame.

FIG.6

Back leg installation.

The same opening is used to allow the interliner pipe to enter as well. After the truck loaded interliner pipe has entered the interior of the base frame, the hoist blocks are attached to the east end of the interliner pipe and the pipe is rotated and hoisted to a vertical position so that it may be lowered down the shaft to the invert and its final destination within the driven tunnel.

The second floor of the base frame structure supports the hoist house control room. From here all hoisting functions and shaft cover movement is controlled. A stair tower and walkway allow access to the control room and to the muck and supply head frames.

Muck head frame, dump scroll, chute and back wall. The muck head frame is a prefabricated structure that measures 4 x 6 m (12 x 21 ft) with an overall height of 28 m (94 ft). The entire muck frame complex which includes the dump scroll, chute and sheave deck is supported on heavy beams that are a part of the upper portion of the previously described base frame.

To allow the rotation and the dumping sequence of the 15 m^3 (20 cu yd) muck boxes, a portion of the north face of the muck head frame is completely open and designated as the dump slot. Because of the complete lack of bracing in this portion of the frame, an external frame work truss is attached to the two legs of the muck head frame to reinforce the legs of the frame in this area.

The dump scroll consists of two heavy plates attached to the north-east and north-west legs of the muck head frame. This heavy plate structure supports two tracks that allow the bail supported muck cars to rotate and automatically dump 15 m^3 (20 cu yd) of tunnel muck onto the chute which is also supported from the northern legs of the muck head frame. This dumping method is a mining technique, well known as a "Kimberly" dump.

The dumped material from the 15 m^3 (20 cu yd) box is slowly displaced and falls onto the dump chute which measures approximately 8 m (27 ft) in length on an angle of 42° to the horizontal. A portion of the dump chute is supported on the top deck of the base frame in addition to the muck head frame support. The upper surface of the muck chute and the impact area is lined with two layers of steel plate and a layer of anti-abrasive material designed to protect the chute, provide a low coefficient of sliding friction and lower the sound of material being dispersed.

The top section of the muck head frame consists of a series of heavy beams that support the sheave deck and three wire rope sheaves. The main sheave that is attached to the muck bail has a pitch diameter of 118 cm (46.5 in.) and supports a 3.8-cm (1.5-in.) diameter Briden Endurance Dyform 34LR Max wire rope with a breaking strength of 151 t (166 st). This wire rope is two parted around a 145-cm (57-in.) diameter Crosby block and returns to the sheave deck where it is anchored in a fixed support frame.

The two remaining sheaves are designated as guide rope sheaves and have a pitch diameter of 71.4 cm (28.125 in.) and support a 2.8-cm (1.125-in.) diameter Briden Dyform 6 wire rope with a breaking strength of 78 t (82.5 st). The two guide ropes are used to guide the muck bail while running in the shaft and are anchored at the foot of shaft by way of a hydraulically operated cylinder designed to measure the required tension in the rope guides.

Supply head frame. The supply head frame is a pre-fabricated structure that measures 3 x 7 m (9 x 22 ft) with an over-all height of 14 m (46 ft). The supply frame, like the muck head frame, is supported on heavy beams that are a part of the upper portion of the previously described base frame. The supply sheave deck is of similar design and configuration as the muck sheave deck with identical sheaves and wire ropes for ease of design and functionality with the double drum hoist for synchronized loads.

The supply head frame is used to support the required services of the underground works for the transport of tunnel rail, tunnel supplies and precast segmental liner. The two guide ropes are used to guide the precast segment handling device and other supplies while running in the shaft which are also anchored at the foot of shaft.

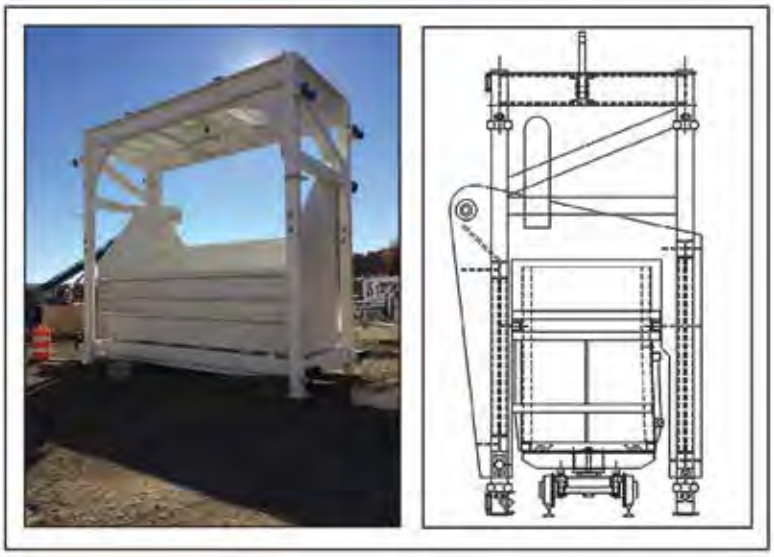
Muck and supply back leg with erection frame. Both the muck and supply head frames have inclined back legs designed to support the loading from the two 3.8-

cm (1.5-in.) diameter main ropes as well as the four 2.8-cm (1.125-in.) diameter guide ropes. The loading from these wire ropes can impose a force of up to 49,270 kg (102,000 lbs) of compression into the back-leg structure. The lengths of the muck and supply back legs are 48 and 32 m (159 ft and 105 ft), respectively, and they are horizontally supported laterally at mid and one-third points along their lengths.

It is virtually impossible to erect these long back legs in one piece so a back leg erection frame is designed and fabricated to allow reasonable sections of the back legs to be erected as units including the attached lateral support struts. The erection frame is outfitted with varying length wire rope slings so that dual sections of the back legs may be raised from a horizontal position on the ground to a predetermined and accurate inclined position in the air to accommodate connections to the two head frames and the foundation anchors on the ground.

FIG.7

Muck bails for drill-and-shoot and TBM operations.



Twenty-eight person personnel cage and access platform. Personnel ingress and egress to and from the shaft invert is undertaken with the use of a specially designed two-level personnel cage capable of transporting 28 people. The lower section of each level is enclosed with solid plate, whereas the upper half of each level has a fine mesh enclosure. The entrance to the cage is by way of three sliding doors, two on the lower level and one sliding door on the upper level.

The personnel cage is raised and lowered with a single wire rope that is supported from a personnel sheave located on the top deck of the base frame structure. The base frame structure supports a sheave deck and three wire rope sheaves. The main sheave that is attached to the personnel cage has a pitch diameter of 98 cm (38.75 in.) and supports a 3.1-cm (1.25-in.) diameter Briden Endurance Dyform 34LR wire rope with a breaking strength of 110 t (122 st). The two remaining sheaves are designated as guide rope sheaves and have a pitch diameter of 71.7 cm (28.25 in.) and support a 2.85-cm (1.125-in.) diameter Briden Dyform 6 wire rope with a breaking strength of 75 t (82.5 st). The two guide ropes are used to guide the personnel cage while running in the shaft and are anchored at the foot of the shaft.

Access to either level of the cage at the collar level is by way of a personnel access platform with an internal stairway that is prefabricated and located inside the south end of the base frame structure. This access platform also allows for a method of traversing from the west side to the east side of the shaft area. Access at the foot of shaft is by way of a 10-m (30-ft) high stair tower.

The personnel cage is equipped with a broken rope safety device installed on each end of the upper framework of the cage. The safety device utilizes a linkage system and a heavy coil spring to activate a pair of high strength serrated wedges that, when activated, grip the 2.85-cm (1.125-in.) diameter rope guides. The cage

FIG.8

Timberland double drum hoist diagram.

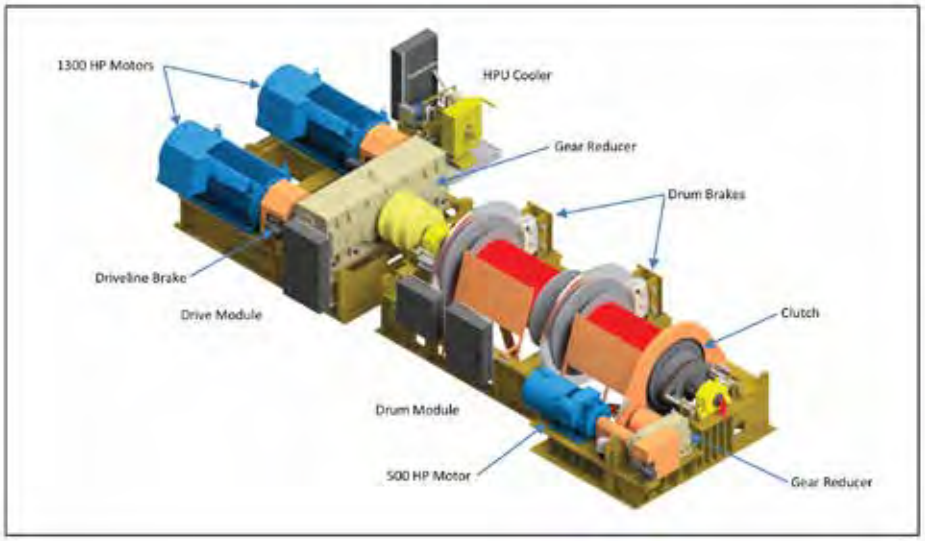


FIG.9

Timberland E-house building and hoist layout prior to hoist house installation.

is guided throughout the shaft area with a total of four bronze thimbles located on the four corners of the cage.

Muck car bails and muck cars. The excavation of the tail and starter tunnels is with the use of the drill and shoot method. The excavation of the main tunnel drive is with the use of a 6.7-m (22-ft) diameter Robbins TBM. The TBM deposits muck into a series of 15-m^3 (20-cu yd) lift off box muck cars from a trailing conveyor belt system and is transported with a diesel powered locomotive.

When the train reaches the area at the foot of the shaft, each successive car enters into a bail structure that is designed to raise the lift-off box only to the surface dump area. The bail system consists of an inner and outer bail. The inner bail is pinned at one corner to the outer bail so that it can rotate and dump the contents of the 15 m^3 (20-cu yd) box while traversing through the dump scroll on the north face of the muck head frame. The combination of bail, box and tunnel muck weighs approximately 48,000 kg (106,000 lbs) and travels to the surface at a maximum velocity of 167 m/min (550 ft/m).

FIG.10

Hoisting equipment inside hoist house.

Hoist requirements and specification

The main mucking and material hoist is a double drum electrical variable frequency drive (VFD) hoist that has two drums capable of running simultaneously locked together or independently. The hoist consists of three separate modules; the main drive module, the drum hoist module and the HPU module. The main drive module has two 970-kW (1,300-hp) electric drive motors directly coupled to a two-speed gear reducer with two high speed input shafts and one low speed output shaft. The primary feed for these drives is 4160V. The drum module has a 480V 372 kW (500 hp) drive motor that transmits torque through a gear reducer with a final bullgear reduction acting directly on the supply drum. Depending on the mode of operation, the two 970-kW (1,300-hp) drives can drive one or both drums through the single shaft at various speeds and capacities. Similarly depending on the mode of operation, the 372-kW (500-hp) drive can drive one or both of the drums through the bullgear with slower speeds and less capacity. With that said, when the hoist is configured correctly, the muck drum can be driven at high speeds from the two 970-kW (1,300-hp) motors at the same time the supply drum can be driven by the 372-kW (500-hp) motor.

The HPU module provides hydraulic pressure for the brake system, the clutch system and the shifting for the two-speed gear reducer as well as cooling the gear oil. Each drum and driveline has an independent brake system spring applied, hydraulically released that is capable of stopping and holding 150 percent of the linepull. The clutches are engaged and disengaged from each drum independently using hydraulic cylinders allowing the hoist to be operated in various modes.

The electrical setup for the main hoist is extensive. The incoming feed to the electrical hoist pad is 13,200 V, which then steps down to 4,160 V for the two 970 kW

(1,300 hp) or medium voltage drives and steps down again to 480 volts for the 372-kW (500-hp) or low voltage drive. Each of the three motors is driven with a VFD. The two 970-kW (1,300-hp) drives are regenerative drives that reduce the harmonics to less than 5 percent distortion so that the power generated by the drives can be put back into the grid as reusable power. The low voltage 372 kW (500 hp) drive dissipates the energy produced through a separate brake resistor. A requirement of the hoist manufacturer was to provide an electrical switchgear building to house all of the drives, control equipment and communication systems with plug and play connections for the main hoist feeds. This allowed the manufacturer to permanently install all of the major electrical components, test the equipment and ship the building as a single unit to avoid tear down, packaging and resetting up of the equipment. This was a significant time and cost savings on the job and simplified the site commissioning.

The double drum hoist has six modes of operation;

- Mode 1: The muck/supply mode is set up to have the two drums run independently. The muck drum primarily for high-speed mucking cycles while being able to hoist materials on the supply drum. The muck drum has a line speed of 5.5 m/sec (1,100 ft/m) with a linepull of 28,210 kg (62,210 lbs) and the supply drum has a line speed of 2.5 m/sec (500 ft/m) with a linepull up to 14,890 kg (32,650 lbs).
- Mode 2: The double-drum heavy lift mode operates with both drums clutched in together utilizing the two 970-kW (1,300-hp) drives providing a total lifting capacity of 113 t (124.4 st) at 0.25 m/sec (50 ft/m).
- Mode 3: Also utilizing the two 970 kW (1,300 hp) drives, the double-drum, high-speed mode operates with both drums clutched in together providing a total lifting capacity of 56.4 t (62.2 st) at 1.27 m/sec (250 ft/m).
- Mode 4: The muck drum heavy-lift mode runs the muck drum in low speed at 0.25 m/s (50 ft/m) and a capacity of 56 t (62.2 st), utilizing the two 970-kW (1,300-hp) drives.
- Mode 5: The supply drum heavy-lift moderuns the supply drum in low speed at 0.25 m/s (50 ft/m) and a capacity of 56 t (62.2 st), utilizing the two 970 kW (1,300-hp).
- Mode 6: Emergency mode runs both drums from the 372-kW (500-hp) drives if the two 970-kW (1,300-hp) drives or gearbox were to fail.

FIG.11

Timberland double drum installation.

FIG.12

Timberland personnel hoist and 28-person cage.

FIG.13

Operator's cab and lowering of the TBM cutterhead.

Personnel ingress and egress is achieved with Timberland's model PH250 and a 28-man, two-level cage. The hoist will lower personnel the 274 m (900 ft) at a rate of about 1.2 m/sec (240 ft/m). The hoist is a single drum, electric over hydraulic hoist system that incorporates a hydrostatic drive and two independent braking systems similar to the brakes on the main hoist. The system is powered utilizing two independent 186 kW (250 hp) electric motors direct coupled to the hydraulic pumps providing a spare pump drive all the time. The control for this hoist is fed back to the operator's cab in the headframe using a single joystick and HMI screens. For emergency purposes, the 480 V power for the personnel hoist system is feed from the essential services switchgear on site that includes backup generator power. For this reason the PLC for the personnel hoist is independent of the remainder of the hoist system and is located at the HPU with a local operator's station for setup and operator control during a power outage.

The hoist system includes six guide-rope winches, two for each of the three main drums; muck, supply and personnel. These winches were primarily used during the sinking of the shaft as the depth continued to increase. Once the bottom was established the guide ropes are fixed and the drums locked. Each winch is a single drum electrically powered with a 15-kW (20-hp) motor and a gear reducer between the motor and drum with a linepull of 3,175 kg (7,000 lbs). The winch has a single spring brake within the motor and a locking dog that is engaged once the guides are set.

Four stage hoists were utilized in the system as well to raise and lower a full diameter shaft work deck for the installation of all the utilities and have a linepull capacity of 16,700 kg (36,980 lbs) each. Each hoist is controlled with a single 15-kW (20-hp) electric motor through a gear reducer and a set of open gears. The brake system consists of a fast acting motor brake and an air controlled band brake. The control for these four hoists are also in the operator's cab within the headframe.

Operation controls

The controls for all of the hoists were set up in a 2.4-

FIG.14

Completed headframe and hoist house.

x 2.4-m (8 x 8-ft) cab to be operated with one operator utilizing three joysticks for the main hoists, two HMI display touchscreens and a series of control panels. Traditionally, the operator's station is positioned in the hoist house overlooking the hoists. However, it was decided to place the cab inside the headframe structure over the shaft cover. This allowed the operator an unobstructed view of the cover and rigging operations as well as providing the safest viewpoint for personnel. The main PLC cabinet for the hoist system was located in the cab along with the load cell control cabinet and CCTV equipment. Additionally, there were controls designed and installed by KSC that were tied into the hoist control system for the anti-two block systems, the load cell system, personnel cage proximity switch and door locks and muck dumping proximity switch.

Set up and erection

The assembly of the hoist and head frame consisted of three phases of work; foundations, preassembly and erection over the shaft. The foundations were poured for the runner beams, base frame, back legs and the hoists, which included 35,000 kg (77,000 lbs) of rebar and 920 m^3 (1,200 cu yd) of concrete. The most challenging piece of the foundations was assuring the embedded bolts for the double-drum hoist were accurately laid out, as the two skids weighed 91 t (100 st) combined and needed to be placed so that the drive output shaft and the drum shaft were perfectly aligned. Preassembly of the structure included the shaft cover, the muck and supply towers, the sheave decks, the base frame and the back legs, all of which took place on site yard while the site utility, shaft utility and foundation work were being performed. Once shaft utilities were completed, the assembly over the shaft began with the base frame. The base-frame stair tower was installed prior to installing the supply tower and lower muck tower for easy access from the deck to all of the tower mounting base plates. Similarly, the upper stair tower was installed prior to the upper muck tower eliminating the need to work out of a 57-m (185-ft) man lift. Lastly the back legs were pinned to the towers and secured to the foundation slab.

Once all of the structural steel was in place, rope up of all the hoists was completed along with the electrical and mechanical installations throughout the hoist and head frame assembly. The technical hook ups and commissioning took an additional few weeks to complete. The crews used throughout the setup were made up of ironworkers, laborers, mechanics and electricians along with assistance from the hoist manufacturer.

Commissioning and testing

There were three phases to the commisioning of the hoists; at the factory, on site and finally the tuning of the medium voltage drives. Timberland performed a factory acceptance test in their plant prior to the equipment being shipped to site. All systems and fuctions were tested to ensure minimal troubleshooting on site. Similarly, thorough site acceptance tests were completed once all of the components were installed and functional, which included KSC's control system. The final step was the testing and tuning of the drives for each mode of operation. Tests were performed at different load capacities and speeds as well as floating the load, changing the load simulating loading a muck box, and emergency stopping. These trial runs for each mode were to fine tune the parameters for each drive to adjust for the drift during floating of the load, the inertia settings, and meshing of the low speed and high speed.

By code, the hoist needed to be load tested to a minimum of 110 percent, which was accomplished using a water bag system consisting of two water bags per load block. The water bags were used to calibrate the load cells as well.

Operation and challenges

The job faced many operational challenges that a multiple hoist system had to accommodate. The initial challenge was coming up with a system designed to accommodate all of the operations for the various aspects of the project from high-speed to high-capacity to size constraints with equipment and 12 m (40 ft) lengths of steel pipe lowered within a 9-m (30-ft) diameter shaft. The logistics of keeping up with supplies to match the performance of the TBM excavation as well as quickly changing over to a grouting operation had to be well planned to be well executed. There was also the difficulty of having a fixed hoist system along with a smaller shaft that needed to accommodate many utilities with the conveyance of the 13 various hoists. The most time consuming challenge of the fixed hoist was getting the material and equipment under the hooks and the rigging required to properly place these items down the shaft.

Conclusion

The Rondout West Branch Bypass Tunnel is a complicated and challenging project and the hoisting at shaft 5B was no exception. But with a bit of ingenuity and the right technical expertise the challenges were overcome. At the time this paper was written, the project had successfully completed the drill-and-shoot operation, hoisted various pieces of equipment in and out of the shaft, lowered the heaviest components of the TBM and completed more than 60 percent of the TBM tunnel excavation. ■

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FEATURE ARTICLE

Fox Conference highlights past, present and future of tunnel industry

About 370 underground construction and tunneling specialists attended the George A. Fox Conference.

Each January, tunneling and underground professionals gather in New York City for the George A. Fox Conference. The one-day event offers attendees the opportunity to listen to their peers outline what's new in the underground construction industry, get updates on major projects in North America and have a chance to catch up of old friends.

The conference is put on by the Underground Construction Association of SME. This latest conference attracted about 370 specialists in the industry. The theme for this year's event was "Water Tunnels, Past, Present and Future."

The technical session included talks focused on major tunneling projects, including the massive California Water Fix program and the Massachusetts Water Resources Authority (MWRA) Metropolitan tunnel redundance program in Boston. The conference also included an update on the Gateway Project from Phil Rice from WSP and Mahammed Nasim of Amtrak as well as a Tunnel Industry update.

The following is a sample of a few of the presentations.

Technical presentations

DEP's Tunneling Program Evolution. James Mueller is the agency chief engineer of New York City's Department of Environmental Protection (DEP). Its mission is to plan sustainable infrastructure investments for the future of clean water and the environment in the city and its watersheds, he said. The agency's goals are to synthesize information across bureaus within DEP to allow data-driven decision-making. It is also to optimize internal agency processes and systems related to the implmenation of engineering programs within a structured assessment process. The agency also prioritizes projects and funding within a structured integrated planning process. And it standardizes project performance and delivery to meet the needs of the agency in alignment with industry standards and market capabilities.

The DEP's Bureau of Water Supply manages New York City's 485,640-ha

by Steve Kral, Editor

(1.2-million-acre) watershed, of which more than 51,400 ha (127,000 acres) are owned by DEP, Mueller said. The bureau supplies more than 3.7 GL (1 billion gal) of quality drinking water daily to more than nine million residents of the state. And the Bureau of Water Supply manages the 19 reservoirs and three controlled lakes with a storage capacity of 2.19 TL (579 billion gal), he said.

The agency's Bureau of Water and Sewer Operations distributes drinking water throughout the city and collects sewage and storm water through 21,000 km (13,000 miles) of sewer and water mains. The bureau also oversees enforcement of regulations governing water-service lines, sewer connections and cross connections, in addition repairing and maintaining DEP infrastructure.

Meanwhile, the city's Bureau of Wastewater Treatment treats 4.5 GL (1.2 billion gal) of wastewater daily, Mueller said. The bureau maintain 14 wastewater treatment plants, 96 pumping stations, four CSO storage facilities and 210 km (130 miles) of interceptor sewers.

Mueller went on to explain the DEP's drinking water tunnel program, using the Kensico-Eastview Connection Tunnel as an example. The goals of the project are to enhance operational resiliency and redundancy, provide target capacity to meet future water demand and enable Catskill aqueduct bypass of the Kensico Reservoir. Other goals of the project are to facilitate emergency and planned outages, provide compatibility with future projects and enable the future bypass of the CDUV facility.

There are several significant factors in the decision-making process for drinking water tunnels and CSO storage tunnels in New York City, Mueller concluded. Durability is one of them. Once in place, tunnels are generally secure assets with long expected lifespans for more than 100 years, he said. So there is a need to plan for future conditions over the 100+ year timeframe.

MWRA Metropolitan Boston Tunnel Redundancy Program project update. Kathleen Murtagh is director of the MWRA. Fred Brandon is director of MWRA' Design and Construction Tunnel Redundancy program. They said the MWRA provides wholesale water and sewer services to more than 3.1 million people and more than 5,500 industrial users in 61 Massachusetts communities.

The authority's primary mission is to modernize the area's water and sewer systems and clean up Boston Harbor. Other priorities are to oversee major capital programs to repair and upgrade the systems, promote

The George A. Fox Conference, held in New York City in January, included nine technical presentations.

water conservation and plan for the future to meet growing demand for water and sewer services. The two provided a history of water transmission systems in Massachusetts, dating back to the Cochituate Aqueduct in 1840s through to the MetroWest water supply tunnel in 2003.

They discussed the damage done and repairs needed when a water main broke in May 2010. After a surface pipe burst, more than 80 million gallons of potable water was discharged to the Charles River before the flow was shut off. The Hultman Aqueduct was shut down for repair and was unable to be used as a backup. A state of emergency was put in place, and about two million people were told to boil their water. Many manufacturers, businesses and restaurants had to be closed until emergency repairs were made. The repairs took two days to complete, but the cost amounted to about $208 million per day for businesses and $102 million per day for residents.

So there is critical need for redundancy in the Metropolitan tunnel system. Valve reliability for the Metropolitan tunnels is a concern, Murtagh and Brandon said. Without the ability to close and then reopen valves, there is no way to isolate a portion of the tunnel system. Many valves need to be replaced, they said, that cannot happen because the City Tunnel would need to be shut down while the valves are being replaced.

One alternative to gain redundancy in the city's water tunnel system involves building two tunnels. The Northern Tunnel would 7.2 km (4.5 miles) long and would connect to the midpoint of the WASM in the Waltham/Belmont areas. The Southern Tunnel would be 15 km (9.5 miles) long and would connect with Shaft 7C. Together, the project 17-23 years to complete, they said.

This alternative would meet several objectives. It would provide redundancy for the entire Metropolitan tunnel system. It would also provide normal water service and fire protection if the existing tunnel system is out of service. It would be designed to meet high-day demand, with no seasonal restrictions. And the alternative provides the ability to perform maintenance on existing tunnels year-round.

Update on the State of California Waterfix Tunnel Program. Sergio Valles is intermin chief engineer for California's Waterfix program. The Sacremento/San Joaquin Bay Delta region near Sacramento is the hub of California's water supplies, Valles said. It is a highly altered and highly studied area. Some areas in the region are 100-percent dependent on Bay-Delta supplies and critical to the state's population and economy.

California Waterfix is important to the state, he said. Twenty-five million people rely on water from the Bay-Delta region from San Francisco to San Diego. More than 1,214,100 ha (3 million acres) of farmland rely on water from the region, and Delta fish and wildlife depend on a healthy Delta ecosystem.

Waterfix is proposing to drive two water transmission tunnels in the region to keep up the state's increasing needs for water. Each of the tunnels will be 50 km (30 miles) long and 46 m (150 ft) below grade, he said. Concrete liners 0.6-m (2-ft) thick will be used and a pressurized face tunnel boring machine will bore an excavated diameter of14 m (45 ft) with a 12 m (40-ft) internal diameter.

More than 700,000 segments will be transported by barge and truck. More than 849,510 m^3 (30 million cu yd) of reusable tunnel material will be moved. About 141,585 m^3 (6 million cu yd) of concrete will be needed, and more than 200 MW of power will be required to drive the TBM. The overall cost will be about $16.7 billion, including $401 million in environmental mitigation costs and $16.33 billion in conveyance system costs.

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The Rapid Excavation and Tunneling Conference is set for June 16-19, 2019 in Chicago, IL. This is another event for professionals in the tunneling and underground construction industry to get together, learn from their peers and renew old friendships. Register at www.smenet.org. ■

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Derrick Equipment Company

Founded by H. William Derrick Jr. in 1951, Derrick® Corporation was created to solve some of the most challenging mechanical separation needs of the Mining Industry. At the heart of our present-day offering resides the Integrated Vibratory Motor which was invented by our founder and gave life to an entire line of innovative separation technology. To this day, our pioneering spirit pulses through the organization and inspires development of our leading-edge solutions.

Over the years, we have experienced exponential growth, expanding from our Mining roots to Oil & Gas Drilling, Civil Construction, Industrial, and other challenging markets worldwide. Our robust installed base and expansive network of thousands of cohesive individuals are located across the globe. Our success is fully dependent on people. Priority one is to serve our global families; our tenured employees, multi-national partners, and surrounding communities. Our unique, close-knit culture and shared, long-term outlook is not only paramount to our success, but to the success of all integral stakeholders.

SERVING THE DRILLING AND TUNNELING INDUSTRIES

Derrick has offered premium slurry separation and desanding equipment to the worldwide Microtunneling, Horizontal Directional Drilling, Large Diameter Tunneling, Slurry Wall/Foundation Drilling, Water Well Drilling, and other Civil Construction industries for nearly 30 years.

Throughout this time, Derrick has remained dedicated to complete in-house manufacturing of every machine, screen panel, and tank system. Each unit is created and assembled at Derrick's Buffalo, New York headquarters facility.

LEADING-EDGE EQUIPMENT MAKES THE DIFFERENCE

Drilling or tunneling performance is directly related to the overall cleaning ability of the separation equipment. Drilled solids remaining in the slurry have numerous adverse effects on the overall operation, significantly reducing its profitability. Consequently, selecting the proper separation equipment for your fleet is just as critical as choosing the correct drill or tunnel boring machine. Derrick answers this critical need with innovative, high performance solids control equipment proven time and time again to increase the rate of advance while reducing:

- Non-production time
- Hauling and disposal of solids-laden drilling fluid
- Cost of drilling fluid and chemicals
- Water usage and hauling
- Wear on downstream pumps, plumbing, and other equipment
- Environmental impact

CIVIL CONSTRUCTION

Since 1988, Derrick has manufactured innovative technologies for the Civil Construction industry. Derrick's separation technology offers unmatched solids removal performance. Using this equipment and innovative screen technology, customers continuously recycle and re-use drilling fluid, while also controlling drilled solids and impact on the environment.

Our Civil Construction solutions are currently used worldwide by companies that require high-efficiency separation and slurry dewatering in environmentally sensitive and urban environments.

DERRICK

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Houston, Texas 77032 U.S.A.
Office: (281) 590-3003
Toll Free: (866) DERRICK
Fax: (281) 590-6187
Email: info@derrick.com
www.Derrick.com

DERRICK MUD RECYCLING TECHNOLOGY

PATENTED SCREEN SURFACES | COMPLETE SYSTEMS | SOLIDS REMOVAL EQUIPMENT

Derrick's separation technology offers unmatched solids removal performance. Using this equipment and innovative screen technology, customers continuously recycle and re-use drilling fluid, while also controlling drilled solids and impact on the environment. Our civil construction solutions are currently used worldwide by companies that require high efficiency separation and slurry dewatering in environmentally sensitive and urban environments.

Discover more visit www.Derrick.com

Leading-Edge Solutions

The DE-6400™ VFD™ (Variable Frequency Drive) centrifuge offers a robust mechanical design coupled with advanced control technology, enabling it to provide consistent and effective solids control in a wide range of drilling fluid types and drilling conditions.

DE-6400™ VFD™ Centrifuge

Reducing:

- **Disposal Costs**
- **Chemical and Dilution Costs**
- **Total Operating Costs**
- **Environmental Impact**

Increasing:

- **ROP (Rate of Penetration)**
- **Fluid & Solids Handling Capacity**
- **Project Profits**

DERRICK®

Derrick Equipment Company
15630 Export Plaza Drive
Houston, Texas 77032
Toll Free: (866) DERRICK
Web: www.Derrick.com

Keller: North America's Leader in Geotechnical Construction

Facing challenging subsurface conditions is a familiar scenario for tunneling contractors, and as the world's leader in geotechnical construction, providing solutions to these challenges is what Keller does. Keller is an industry leader in safety, quality, and innovation. We have the resources, expertise, and in-depth project experience to resolve even the most complex geotechnical issues.

Keller's leadership is driven by our network of outstanding companies and the people behind them who inspire each other to develop the optimal solutions for complex challenges, both large and small.

Our combination of detailed local knowledge and connected global resources ensures no question goes unanswered, no problem goes unsolved, and no job goes unfinished. We remove the guess work, mitigate the risk, and give you peace of mind knowing your geotechnical projects are in the best possible hands.

Blue Plains DCWASA project

Global strength and local focus

At Keller, the strongest local projects are built on a foundation of connected global expertise. Our companies are positioned to work individually and together as a regional or global group to bring our combined knowledge, experience, financial strength, and reach to tackle the most demanding projects.

Collectively, we've been improving the ground to keep tunneling operations moving along for almost 100 years. Keller's full range of geotechnical construction techniques has been applied to hundreds of tunneling projects to ensure the highest quality product and service.

Northgate Link project

Solutions for tunnels:

- Soil stabilization
- Settlement control
- Groundwater control
- Earth retention
- Dewatering
- Ground freezing
- Access and ventilation shafts
- Soft ground and hard rock solutions
- Mixed face conditions
- Real-time monitoring

Contact us today about your next tunneling project.
Keller
7550 Teague Rd #300
Hanover, MD 21076
Telephone: +410-551-1938
www.kellerfoundations.com

THE CONNECTED COMPANIES OF KELLER IN NORTH AMERICA

ANDERSON DRILLING
A KELLER COMPANY

BENCOR
A KELLER COMPANY

CASE FOUNDATION
A KELLER COMPANY

CYNTECH
A KELLER COMPANY

GEO INSTRUMENTS

HAYWARD BAKER
A KELLER COMPANY

HJ FOUNDATION
A KELLER COMPANY

KELLER

MCKINNEY DRILLING
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MORETRENCH
A HAYWARD BAKER COMPANY

MORETRENCH INDUSTRIAL
A KELLER COMPANY

SUNCOAST POST-TENSION
A KELLER COMPANY

Herrenknecht: Pioneering Undergound Together

With the experience of more than 4,100 projects, Herrenknecht is a technology and market leader in the area of mechanized tunnelling technology. Herrenknecht is the only company worldwide to deliver cutting-edge tunnel boring machines for all ground conditions and in all diameters – ranging from 0.10 to 19 meters. The product range includes tailor-made machines for traffic, supply and disposal tunnels, technologies for pipeline installation as well as drilling equipment for vertical and inclined shafts and deep drilling rigs.

The Herrenknecht Group achieved a total output of 1,208 million euros in 2017. The independent family-run business employs over 5,000 people worldwide, including around 180 trainees. With more than 70 subsidiaries and associated companies working in related fields in Germany and abroad, Herrenknecht is able to provide a comprehensive range of services close to the project site and the customer, quickly and in a targeted way. Under the umbrella of the Herrenknecht Group, a team of innovative specialists offers integrated tunnelling solutions with project-specific equipment and service packages upon request: separation plants, belt conveyor systems, navigation systems, rolling stock systems as well as segment moulds and even turnkey segment production plants.

As a reliable project partner, Herrenknecht supports its customers with an extensive range of services from the beginning of the project to breakthrough. From the initial project idea through manufacturing, transport, assembly, tunnelling support and spare parts service to disassembly, Herrenknecht accompanies the process at the customer's side. Even personnel solutions for the temporary supplementing of jobsite crews are provided if required. With competent service specialists and 40 years of experience in the tunnelling industry, the company regularly supports around 300 jobsites worldwide and offers customized service packages tailored to individual project requirements.

Road, metro, and railway tunnels for efficient traffic network.

By the middle of this century, the world´s population is expected to reach nine billion, and two thirds of these people will live in large conurbations. To keep people and goods on the move, the way ahead for new efficient infrastructures is leading underground. With state-of-the-art technologies, efficient infrastructures are created exactly where they are needed, even in cramped and complex jobsite conditions. Herrenknecht technology pushes the boundaries of feasibility and creates new tunnelling standards worldwide. Herrenknecht technology extends existing transport networks and creates new connections in urban and rural areas – under mountains or deep beneath water.

Innovative solutions for underground supply and disposal systems.

As the world's population grows the need for underground supply tunnels is also increasing; in emerging and developing countries as well as in modern metropolises. That is why more than 850 Herrenknecht Utility Tunnelling Machines are in operation around the world constructing or laying water and wastewater systems, gas and oil pipelines, as well as conduits for electricity and telecommunications. Here, trenchless tunnelling technology offers a range of advantages compared to conventional construction procedures: transport, business and the environment remain mostly undisturbed when Micromachines, HDD rigs or shaft sinking equipment are being used. Innovations such as Direct Pipe® set new standards in the semi-trenchless installation. The new technology E-Power Pipe® allows the secure and quick installation of underground cable protection pipes with smaller diameters and long advance lengths. Innovative HDD tools simplify pipeline construction operations at key sections. The Herrenknecht product portfolio is completed by a broad range of equipment for the areas of mining (construction of underground infrastructures around raw material deposits) and exploration (oil, gas and geothermal energy).

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HERRENKNECHT
Tunnelling Systems

The Robbins Company

Driven to the Core

Today's tunneling projects are more complex than ever—squeezing ground, fault zones, and water inflows are just a few challenges you may face. Even in the most well-planned projects, unknown conditions can interrupt your progress. That's why it helps to have a team of experts on your side. Robbins is a total supply company offering customized equipment, knowledgeable field service personnel, and technical support. Each piece of equipment, from our TBMs to our conveyors, is engineered for maximum durability and premium performance. With over 65 years of tunneling behind us, we can confidently say that experience is our greatest asset.

A Massive Mixed Ground Undertaking

Robbins recognizes the importance of having the right machine for each unique project. With a range of products for soft and mixed ground conditions, from Slurry Shield TBMs to EPBs to Crossover machines, we've got you covered.

India's Mumbai Metro Line 3 is an example of a particularly challenging project, with multiple contracts in variable geology. Under contract UGC03 for the Dogus-Soma JV (DSJV), twin 6.65 m (21.8 ft) diameter Slurry Shield TBMs are excavating parallel 3.5 km (2.2 mi) long tunnels. The Slurry Shield machines are boring in fresh to weathered basalt and breccia up to 100 MPa UCS (14,504 psi) with water pressures up to 3 bar.

Twin 6.65 m (21.8 ft) Crossover XRE TBMs are also excavating under a separate contract, UGC-01. Larsen & Toubro, part of the Larsen & Toubro-Shanghai Tunnel Engineering Co Joint Venture (L&T-STEC JV), is operating the machines. The XRE TBMs (a combination of hard rock Single Shield TBM and Earth Pressure Balance Machine) are boring parallel 2.8 km (1.7 mi) long tunnels in mixed ground and water pressures up to 2 bar. Rock strengths range between 15 MPa and 125 MPa UCS (2,200 and 18,100 psi).

Your Go-To Machine in Hard Rock

In hard rock, no machine bores faster than a Main Beam TBM. Pair that with Onsite First Time Assembly (OFTA)—a Robbins developed method of initially assembling the machine at the jobsite—and you can tackle even the most aggressive project timeline. Such was the case at the Atlanta Water Supply Program in Atlanta, Georgia. With an overall project completion date of September 2019, TBM assembly and tunneling had to adhere to a strict schedule. The 3.8 m (12.5 ft) Robbins Main Beam TBM was built using OFTA in the inactive Bellwood quarry. The program will convert the quarry into a 9.1 billion liter (2.4 billion gallon) raw water storage facility.

The tunnel was completed ahead of schedule with the machine's breakthrough occurring in October 2018. To accomplish this, the Main Beam had to bore through extremely hard rock conditions along a curving 8.0 km (5.0 mi) tunnel. Rock strength ranged between 117 and 310 MPa UCS (17,000 and 45,000 psi), which proved challenging at times. Despite groundwater and extremely hard rock, crews still managed a best day of 38.4 m (126 ft).

The Robbins Company
Telephone: +1 (440) 248-3303
www.TheRobbinsCompany.com

DRIVEN TO THE CORE

SOLUTIONS FOR DIFFICULT GROUND

Akron Ohio Interceptor Tunnel Project
Akron, Ohio, USA
Robbins 9.26 m Crossover XRE TBM

POWERING THROUGH TOUGH GEOLOGY IN OHIO

From start to finish, crews at the Akron Ohio Canal Interceptor Tunnel guided North America's largest Crossover XRE TBM through soft ground, partial face shale and full-face rock, all while achieving advance rates up to 34 m per day.

therobbinscompany.com

Robbins
RELIABLE | RESPONSIVE

Local Presence. Global Competence.

DSI Tunneling LLC offers a complete selection of ground control solutions for the Civil, Mining and Foundation markets. We have been a leader in the underground support business in North America since 1920.

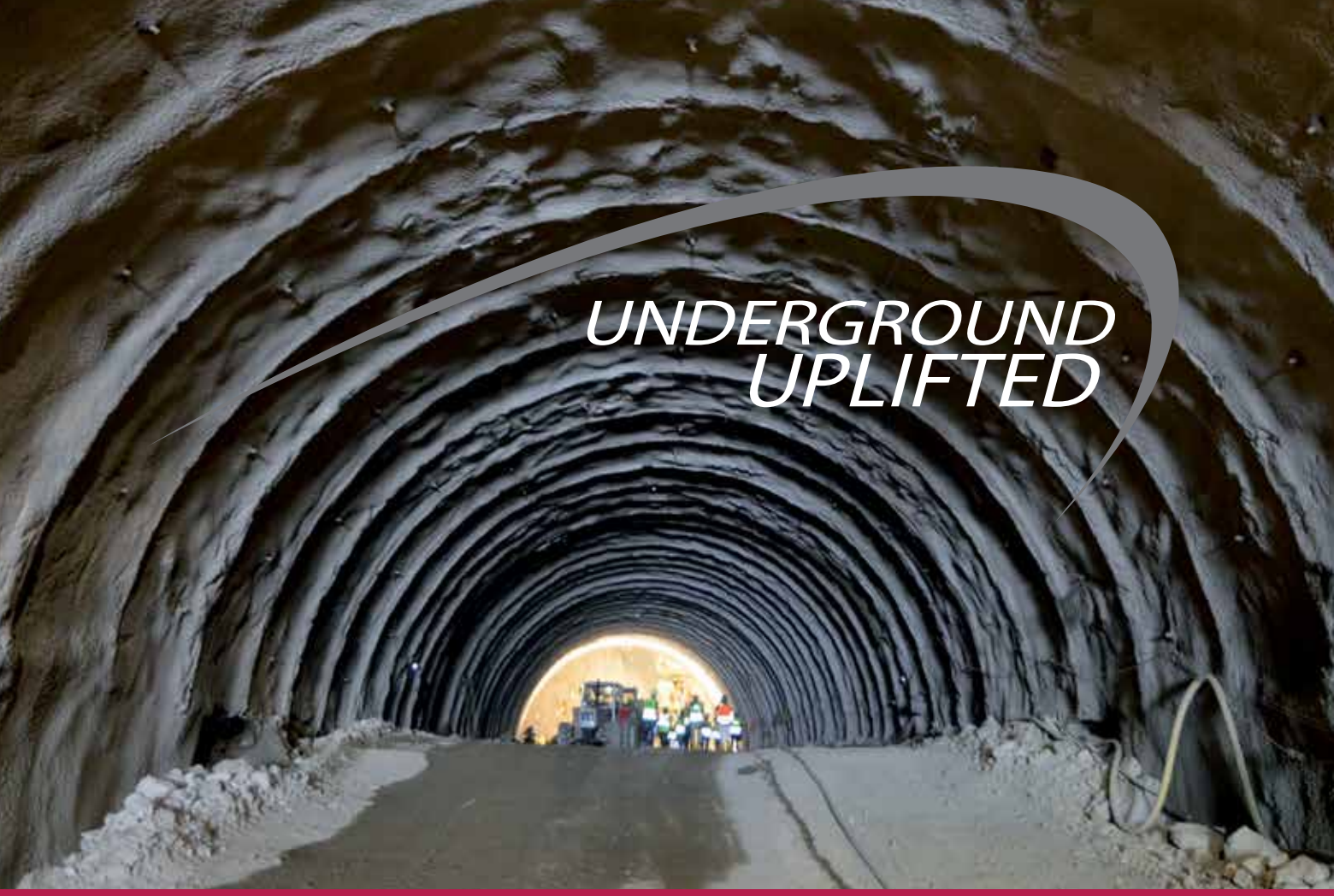
We are a global leader in tunnel and shaft structures, focused on engineered and tailored products to support our customers and industry.

DSI Tunneling is proud to bring an expanded group of products to the job site:

- ALWAG - Support Systems
- Biomarine - Tunnel Rescue Equipment
- Boart - Probe and Roof Bolting Equipment
- Condat - Ground Conditioning Chemicals and Lubricants
- DSI - Steel Ribs, Liner Plates, Lattice Girders, Lagging and Miscellaneous Support Items
- DSI Schaum Chemie - urea-formaldehyde foams, Polyurethane adhesives, organic mineral adhesives, cement binders.
- Dywidag - Bolts and Accessories including DSI Threadbar, Forepoling Systems, Friction Bolts and Omega Bolts
- Hany - Grouting Systems
- Montabert - Excavator Drilling Attachments and Replacement Drifters
- Promat International - Fire Protection Products
- Strata Worldwide - Safety and Communication Equipment
- VikOrsta - CT-Bolts - Double Corrosion Protection
- Weldgrip - Fiberglass Bolts and Dowels

DSI UNDERGROUND

www.dsiunderground.com
502.473.1010



www.dsiunderground.com

Leader In the Design, Development, and Production of Underground Steel Supports in North America.

We offer full service support:

- Engineering Estimates
- Design Collaboration
- Contractor Shop Drawings
- Construction Support

DSI UNDERGROUND

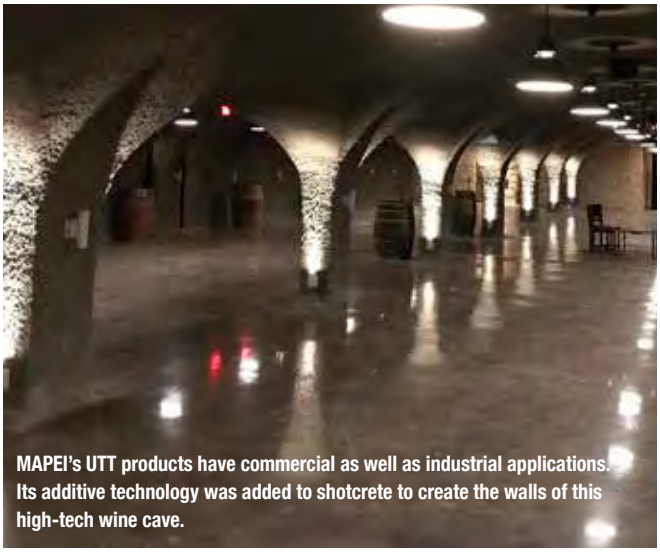
DSI Tunneling LLC
502-473-1010

MAPEI Corporation

MAPEI's Underground Technology Team (UTT) provides the construction market with a range of products dedicated to underground construction work. MAPEI's UTT group and the products it represents were created to meet the expectations of these challenging environments.

From the project specification to the admixtures for shotcrete and concrete to the final protective coatings, MAPEI's UTT group and technology are there "for the whole job," said Bill Allen, UTT Business Development Manager — Tunneling. The UTT group is a successful division of MAPEI Group, which has provided proven construction system solutions for more than 80 years.

MAPEI's UTT products were used to help a tunnel boring machine dig the Anacostia River Tunnel, which extends for 2.37 miles from Robert F. Kennedy Stadium in northeast Washington, D.C., to Poplar Point in southeast D.C.



MAPEI's UTT products have commercial as well as industrial applications. Its additive technology was added to shotcrete to create the walls of this high-tech wine cave.

Established in 1937, MAPEI Group is a global corporation, based in Milan, Italy, and with 87 subsidiaries that include 81 plants in 35 countries. MAPEI is the world-leading manufacturer of mortars, grouts and adhesives, as well as complementary products for installing floor and wall coverings. MAPEI manufactures chemical products for building, including waterproofing products, admixtures for concrete and repair products, and decorative and protective exterior coatings — as well as the UTT product line.

"The UTT group started in earnest in the U.S. in 2015," stated Wesley Morrison, UTT Regional Manager – North America. "But the business has grown substantially since then."

In the underground industry, speed is essential – not only of the products themselves, but also of the evolution of technology. MAPEI reinvests a considerable percentage of its annual profits back into research and development to maintain a leading technological advantage.

MAPEI's commitment to R&D ensures that the UTT line comprises the most innovative and technologically advanced products available. In addition to the latest in cutting-edge products, the UTT team is trained in their use.

The UTT product line is divided into six categories: Concrete; Injection, consolidation and anchoring; Waterproofing; Renovation, maintenance and repair; Coatings for underground construction; and Mechanized tunneling.

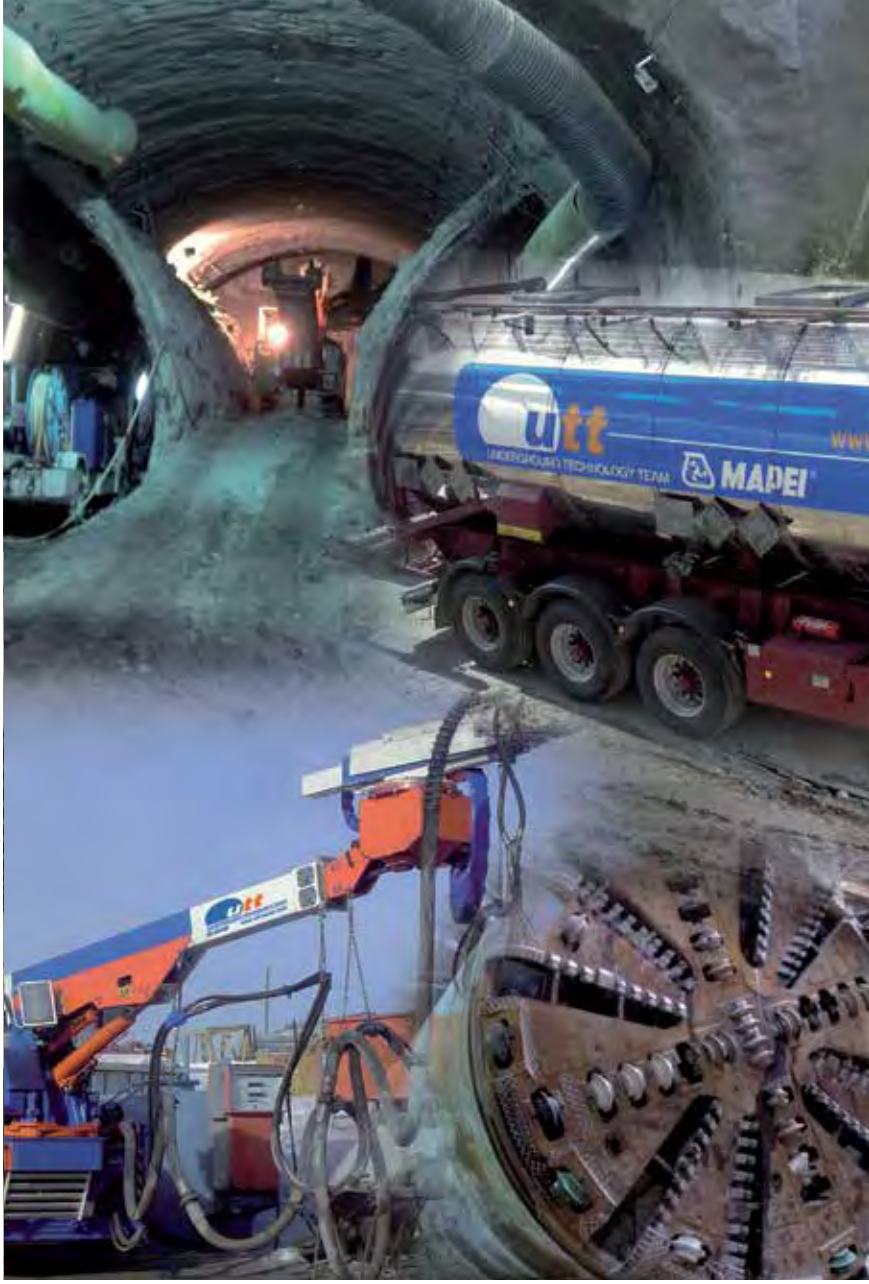
No matter the division or the product line, MAPEI is known for quality products and for providing system solutions. As Allen stated, "The distinguishing point for UTT is our field support, and our applied technology in the field. Simply put, we don't just sell a product, but rather we go into the field and help our customers use our products – on their jobsite, with their conditions, personnel and equipment."

Morrison concurred, agreeing that UTT's technical services and agility are unbeatable. "We service a project from the very beginning to the very end like no one else in the industry does," he said. "We also have the agility to adjust to the customers' needs when necessary."

For more information, contact MAPEI's UTT group at www.utt.mapei.com.

Proven Technology for

Underground Construction



Our commitment is the detail that makes the difference.

Reliable technology and expertise for underground construction

- Alkali-free set accelerators and admixtures for shotcrete
- Products for mechanized tunneling: foaming agents for soil conditioning, polymers, sealants and lubricants
- Products for grouting and consolidation
- Products for concrete repairing, protection and coating
- Products for waterproofing: synthetic waterproofing membranes and waterproofing accessories

Discover the world of MAPEI: Visit www.utt-mapei.com or email us at hq.utt@utt.mapei.com

MAPEI USA

utt
MAPEI

BASF

The Master Builders Solutions brand from BASF continues to break new ground in addressing the needs of tunneling professionals. Our BASF Underground Construction team brings a total solution approach to your projects, providing an added resource to help meet your challenges underground. Our solution-based systems enhance the efficiency and performance of the TBM operations and offer performance-based ground support solutions, from novel soil conditioning technologies to innovative anchoring systems; no matter the tunneling method. Throughout the life of your project, our team of specialists works with all relevant stakeholders to help maximize your production rates and to ensure the most successful product and system selection.

The MasterRoc product brand offers a wide range of solutions for TBM excavation in soft ground and hard rock, with high-performance products including soil conditioners, polymers and anti-clay agents. Our full-line of greases and sealants help to maximize efficiency for every excavation method and soil type.

Sprayed concrete, bolting, injection and water management systems are also widely considered, selected and used for ground support and enhancement in tunneling. BASF offers customers innovative product solutions and experienced technical resources to tailor cost-effective solutions to specific project needs. These solutions dramatically improve working environments, production and safely.

The Master Builders Solutions product line is designed to be a single source for all of your underground construction needs. In addition to the wide range of products and systems, our globally connected team assists our customers in selecting the right combinations, allowing for successful operations, coupled with the highest safety standards.

BASF, a world leader in reliable solutions specifically designed to address the requirements of tunneling projects worldwide is where production meets performance and safety. Utilizing our global expertise, we are steadfastly focused on the needs of tunneling professionals.

For more information, please visit: https://www.master-builders-solutions.basf.com

Dragados TBM Bertha
Photo credit-Catherine Bassetti Photography

Open Tunnel
Photo credit-Catherine Bassetti Photography

MASTER® BUILDERS SOLUTIONS

SOLVING YOUR UNDERGROUND CHALLENGES

Our customers shape the future. By listening to their needs and challenges, we have developed a complete and comprehensive offering for the tunneling industry.

We continue to focus our R&D efforts on safe, sustainable, innovative solutions for tomorrow‘s challenges.

www.master-builders-solutions.com

BASF
We create chemistry

Photo credit: Catherine Bassetti Photography

HNTB: Trusted Innovative Underground Solutions

Increased demand for more efficient transportation and for reliable power, water and wastewater conveyance, as well as continued growth in the urban core, has led regions and cities to rely on subsurface infrastructure and tunnels. Modern technology, including large-diameter tunnel boring machines, has been contributing significantly to achieving transportation solutions with lesser impacts on overbuilt cities, communities and businesses.

HNTB has more than 60 years of experience in the design, construction and restoration of tunnels and underground structures in various grounds in the highway, transit and rail, aviation and water resources markets. Our experts have the insight and knowledge to provide innovative solutions on a wide range of tunnels. HNTB's long history in planning, program management, design, construction management and technical services for tunnel structures has delivered award-winning projects for some of the country's most complex tunneling projects. We pride ourselves with outside-the-box thinking and delivering innovative solutions for our clients and communities that respond to their long-term objectives.

HNTB provides tunneling and underground engineering expertise, including structure design and support services – from planning through final design and construction. Our full-service capabilities include:

- Program and construction management
- Design of soft ground, rock and immersed tunnels as well as caverns, shafts, cut-and-cover structures
- Micro-tunneling, pipe jacking and New Austrian Tunneling Method
- Condition survey and rehabilitation
- Geotechnical and engineering geology
- Excavation support, protection of existing facilities and underpinning
- Settlement analysis and mitigation
- Seismic design and retrofit
- Geotechnical and structural instrumentation
- Ground improvements and groundwater control
- Tunnel ventilation and fire-life safety design
- Tunnel security and hardening

Among HNTB's recent and notable tunnels projects are:

- SF 99 Alaskan Way Viaduct and Seawall Replacement – Seattle
- Crenshaw/LAX Transit Corridor – Los Angeles
- Istanbul Strait Road Tunnel Crossing – Istanbul, Turkey
- Presidio Parkway – San Francisco
- Washington Dulles International Airport Tunnels – Washington, D.C.
- Tom Lantos Tunnels – San Mateo County, CA

HNTB
www.hntb.com

Trusted INNOVATIVE **UNDERGROUND** SOLUTIONS

Crenshaw/LAX Transit Corridor

HNTB has a long history of award-winning work for some of the country's most complex tunneling projects. From small-diameter excavations to the largest machine-bored tunnel in the world, our experts have the insight and knowledge to provide innovative solutions to tunneling challenges.

Sanja Zlatanic, PE
CHAIR, NATIONAL TUNNEL PRACTICE
szlatanic@hntb.com
(646) 652-9440

The HNTB Companies
Infrastructure Solutions

hntb.com

HNTB

Alaskan Way Viaduct Replacement Program

Putzmeister America, Inc.

Putzmeister has been a global leader in the world of construction and mining since 1958. The company develops, produces, sells and serves customers with high quality and high reliability machines for pumping, distributing and placing concrete, mortar and high-density solids, and for preparing, temporarily storing, processing and transporting these materials. Putzmeister strives to serve customers by delivering the number one customer experience in the industry and this continues to be the mission for the future.

Putzmeister consistently provides innovative technologies that are constantly updated as per the latest research and development, and market requirements. Customizing equipment to the exact needs of customers and providing effective, long-term and simple solutions to complex problems through Putzmeister's hardy and versatile machines. Putzmeister ably and actively partners with clients on projects to help them deliver on their promises. Skilled, committed and motivated teams ensure Putzmeister clients get value for their money at all times and at every location.

World-class products and services set the standards for quality through continuous and significant investment in research and development. To guarantee customers are getting the number one customer experience, Putzmeister provides 24/7 advice and support ranging from the right choice of machines to be used for a construction project to engineering solutions. Putzmeister carries thousands of parts on hand to allow for quicker processing and handling.

Putzmeister machines are used for a range of applications including civil engineering, mining, tunneling, precast factories, large-scale industrial projects and power stations. Putzmeiser combines top-end German engineering, technology, expertise and high manufacturing standards with locally relevant requirements to provide a comprehensive solutions package.

The know-how of Putzmeister is shown in the handling of different material like concrete or mortar and in the conveying of a variety of solids like sewage sludge, coal sludge or mining tailings. On job sites and in industrial facilities worldwide, Putzmeister technology confirms that all machines and installations are working perfectly. Putzmeister's first class products are setting the standard in the industry, especially in terms of sustained and profitable growth for customers. With different pumps and conveying systems, Putzmeister always offers the right machine for every application.

For more information, please visit:
https://www.putzmeister.com/web/americas

DID YOU KNOW?

PUTZMEISTER TAKES UNDERGROUND PERFORMANCE TO NEW HEIGHTS

From small tunnels with difficult access to large tunnels and galleries, Putzmeister delivers the power and precision you need to tackle the toughest subterranean projects. We deliver safe, precise concrete spraying. We ensure you comply with emission regulations. We help you work smarter, better and faster.

Don't settle for subpar equipment. Elevate your expectations.

#PMKNOWS

GENUINE PARTS. EXPERT SERVICE.
Putzmeister keeps you running.

Putzmeister.com • 262.886.3200

Putzmeister

How Can a High-Speed Wi-Fi-Enabled Tunneling Network Operate Without Specialized Staff?

In the past, it would be impossible to install a high-speed network with Wi-Fi and Ethernet communications in a tunneling project without specialized installation and maintenance personnel. N-Connex now makes it possible – and simple. This award-winning, modular plug-and-play network is easy to install, expand and maintain. The cables and extenders come pre-terminated, eliminating the need for on-site splice repairs. And the modular components allow you to customize your network based on environmental conditions and communications requirements.

N-Connex is the most comprehensive and flexible gigabit Wi-Fi network – with the lowest cost per mile – on the market today. Used by forward-thinking mining and tunneling companies around the globe, N-Connex offers a basic network to which multiple solutions can be added. N-Connex's unique design allows third-party electronics and hardware integration, providing a one-stop shop for add-on solutions and eliminating the need for sourcing components.

Tomorrow's communications have arrived

Why have Wi-Fi in your tunnel? The first reason is communications. Voice and data comms enable private calls, PTT broadcast, IP intercoms, phones, tablets, laptops, wireless adapters, input/output devices, tracing tags, radios and more. Reception over Wi-Fi is crystal clear and calm with multiple channels over which you can talk individually or as a group. Additionally, being able to transfer data and get updates provides you with the ability to make changes mid-shift to enhance efficiency and productivity.

Second, the N-Connex tracking solution offers a reliable, detailed and flexible approach to locating personnel, vehicles and assets throughout a project. Tracking also interfaces with a suite of emergency features such as N-Connex's alarm module and advanced evacuation technology. These features alert and help provide the exact location of all personnel in the event of an emergency. Increasing personnel health and safety are primary goals of the N-Connex system.

In addition to tracking, N-Connex offers telemetry data in real-time on vehicles, providing you the ability to remotely monitor the health of your machines, including TBMs, and make adjustments or pre-empt failures. Less down-time means more production.

Most anything you can imagine

N-Connex's suite of solutions is incredibly diverse, typically providing the operator with additional levels of functionality well beyond their initial use cases. In addition to communications, tracking and safety features, it offers a multi-level map interface and zone management, as well as video, real-time condition and environmental monitoring. All of this functionality is packaged in a ruggedized enclosure, specifically designed to withstand harsh environments.

Lowest cost to invest – lowest cost to advance

N-Connex has lowered Wi-Fi access costs, creating a highly affordable networking solution with the lowest cost-to-advance rate on the market. And since you can install a basic system, then add on the adaptable modular features as you go, the network gives you financial flexibility. The simple beauty of the N-Connex system is its ability to meet your exact needs today and address your expansion or available resources tomorrow.

www.matrixteam.com

THERE'S NO OTHER TUNNELING
WI-FI SOLUTION
EASIER TO DEPLOY AND SUPPORT

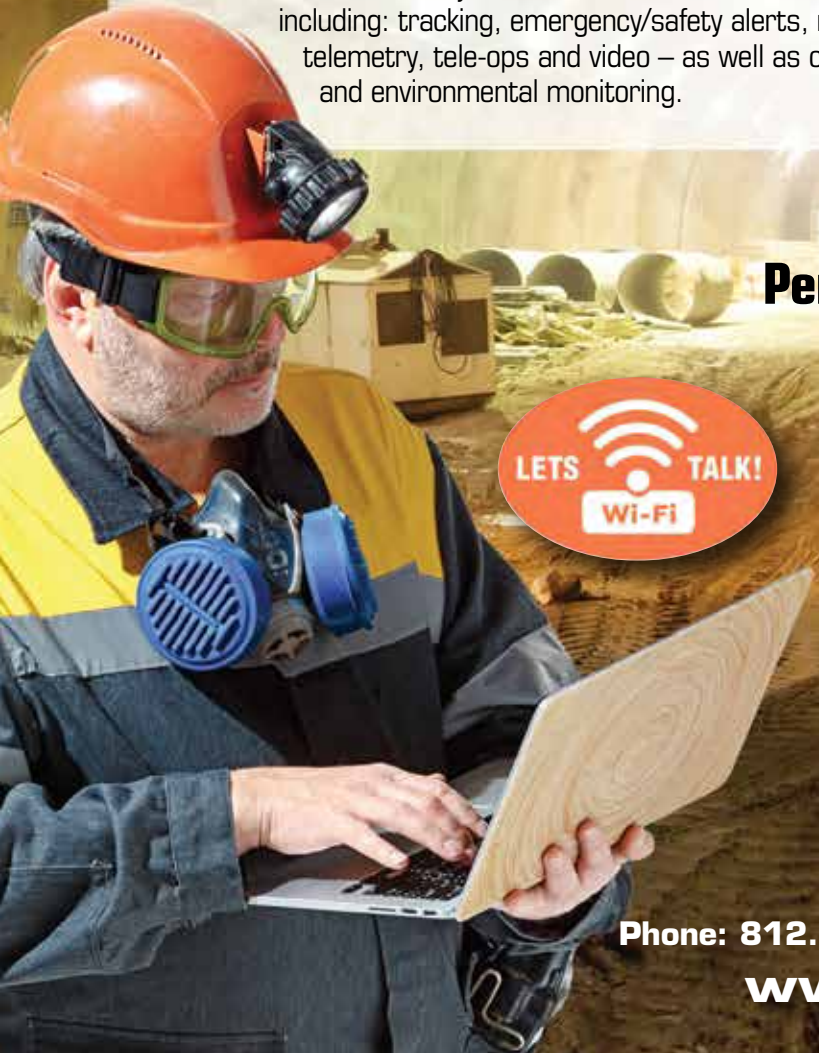
N-Connex
GIGABIT HIGH-SPEED MODULAR NETWORK

N-Connex is a fully integrated network that provides a **Wi-Fi and Ethernet** tunneling solution like no other!

- Pre-programmed modular plug-and-play network can be **installed and supported by existing staff**
- Provides clear, reliable Wi-Fi communications via IP Phones, Smart Phones, IP Radios, Laptops and Tags
- Start with what you need, then add solutions as required, including: tracking, emergency/safety alerts, machine telemetry, tele-ops and video – as well as condition and environmental monitoring.

Matrix is the authorized sales and service distributor of NLT N-Connex in the United States, Europe and Africa.

Lowest Cost Per Installed Mile



MATRIX

Phone: 812.490.1525 • Email: sales@matrixteam.com

www.matrixteam.com

Epiroc

Epiroc is a leading productivity partner for the mining, infrastructure and natural resources industries. Epiroc develops and produces innovative drill rigs, rock excavation and construction equipment, and provides world-class service and consumables.

We focus on efficiency, safety and reliability, delivering the performance you need to maximize productivity today – and the technology to succeed in the future.

Our tunneling equipment includes:

Drilling equipment

We offer drill rigs for blasthole drilling, production drill rigs for long-hole drilling, one of the industry's largest ranges of top tophammer drilling tools, and down-the-hole drilling tools. All are designed for long life and maximum uptime.

Loaders and trucks

Our high-performance underground loaders, haulers and dumpers cover a wide range of hauling capacities and frame styles to fit specific needs. Products include electric loaders, continuous loaders, and diesel loaders and trucks.

Raiseboring

Epiroc offers tools and equipment for conventional raiseboring, boxhole boring and down reaming. These products are designed to reduce fatigue and maximize uptime, with features that enhance operator safety.

Ventilation systems

We supply a complete ventilation solution for tunneling and underground opertions, including system deisng and installation of fan stations and ducting.

Rock reinforcement equipment

We have your rock reinforcement needs covered with machines ranging from low seam to some of the largest mining and civil drive dimensions. Our rock bolting rigs, cable bolting rigs, concrete spraying equipment and ground support solutions are all designed to help customers achieve the highest productivity with the lowest maintenance costs.

Visit Epiroc.us to learn more.

United. Inspired.

We wait for no one. We want to change minds and move markets. Our zero-emission equipment brings massive savings on ventilation and creates a healthier work environment for miners everywhere. The future is electric.

Epiroc

epiroc.us

Surecrete Inc.

Surecrete Inc. specializes in furnishing bagged cementitious materials, mixing and placing equipment and related accessories to the heavy civil tunnel, geotechnical and mining markets throughout the US, Canada and Mexico.

Our product lines include ultrafine cements, rheology modifiers, fibers, admixtures, and a complete selection of packaged shotcrete, concrete and grout mixes. We also supply wet and dry shotcrete machines, predampeners, concrete pumps and grout plants.

19705 Scriber Lake Rd, Ste 103
Lynnwood, WA 98036
Phone: (206) 523-1233
Fax: (206) 524-6972
Email: jeff@surecrete.com
For more information, visit our website at www.surecrete.com.

Schnabel Engineering

Schnabel Engineering, formerly Lachel & Associates, specializes in design and construction management services for tunneling and other heavy civil construction projects in the areas of transportation, water and wastewater infrastructure, and hydroelectric power. Our goal is to meet the needs of clients by providing fully integrated management and technical services that are objective, thorough, and effective.

We combine our expertise in the design and construction of underground structures with a keen understanding of nuances and interrelationship of geology, hydrogeology, and geotechnics on underground projects. From inception, through design, risk assessment, estimating, construction, and operations, we provide time-critical answers to difficult questions that help make certain the project comes in on time and within budget.

Founded in 1956, Schnabel has a long history of providing tunnel design services for constructors, owners, and other A/E firms for project across the United States. Some of our recent projects include:

- DC Water Clean Rivers Program, Washington, DC
- Loudon Water Raw Water Supply Tunnel, Leesburg, VA
- East End Crossing Tunnels, Louisville, KY
- Waller Creek Flood Tunnel, Austin, TX

TUNNEL DESIGN SERVICES
Some of our design services for tunnels and underground projects include:

- Feasibility Studies
- Alignment Optimization
- Assessment of Geotechnical Conditions
- Tunnel Initial and Final Support Design
- Numerical Methods for Design
- SEM / NATM
- Cavern Design
- Shaft Design
- Constructability Review and Cost Estimating
- Geotechnical Baseline Reports (GBRs)
- Construction Documents/Design Reports

www.schnabel-eng.com

Schnabel ENGINEERING
formerly Lachel & Associates

- Tunnel Engineering
- Geotechnics
- Constructability and Cost Estimating
- Risk Management
- Construction Engineering
- Construction Management
- Trenchless Technology
- Tunnel Inspection and Rehabilitation

MORRISTOWN, NJ FAIRFAX, VA DALLAS, TX LAS VEGAS, NV

schnabel-eng.com

Advanced Concrete Technologies, Inc.

– We Add Profitability to the Mix

Advanced Concrete Technologies, Inc. (ACT) is a single source supplier of turnkey concrete batching and mixing plant solutions that draws on over 45 years of experience and more than 5,000 concrete plant installations worldwide. ACT provides the industry's most flexible and proven solution for producing highest-quality, central mixed concrete and backfill grout for on-site construction, tunneling and mining projects. ACT's MobilMat batch plants, come in ten different sizes, ranging from 30 up to 240 cubic yards per hour concrete output. We offer high intensity HPGM counter-current mixers and DWM twin-shaft mixers, advanced WCS control automation, commissioning services as well as an industry leading training & support program.

ACT's plant solutions deliver superior quality concrete with the ideal combination of proven components, engineered by one of the world's most respected names in the industry – Wiggert & Co. GmbH.

Advanced Concrete Technologies, Inc.
300 Portsmouth Avenue
Greenland, NH 03840 USA
Telephone: +1-603-431-5661
www.concretebiz.com

CDM Smith – A Leader in Tunnel Engineering

Urbanization and rapid population growth have increased demand for tunnel and underground engineering to address infrastructure needs and maintenance challenges facing metropolitan areas worldwide. CDM Smith is a leader in underground space and tunnel engineering. Working collaboratively with our clients, we employ our extensive global tunnel design and construction experience to develop holistic and optimal solutions for a wide range of projects.

Tunneling Expertise

With our experience encompassing soft ground, mixed face, and rock tunnels and excavations, CDM Smith offers a unique perspective and skillset that addresses the specific needs of each project. Our capabilities are comprehensive and include:

- Tunnel engineering: Tunnel and trenchless engineering
- Lining design: segmental, sprayed and cast-in-place
- Soil-structure interaction: 2-D & 3-D numerical modelling
- Ground improvement and ground freezing
- Deep excavations and ground support
- Groundwater modelling and control
- Shafts and caverns
- Documenting and baselining geotechnical conditions

To support our clients, we offer consulting, engineering and construction support services including:

- Environmental, permitting and planning process
- Preliminary design through bid/construction support
- Value engineering and peer review
- Program/construction management
- Inspection and rehabilitation of underground structures
- Risk management
- Cost estimation and life cycle cost analysis

Market Sector Experience

Tunneling and ground engineering is unique – it crosses market sector boundaries. CDM Smith's global tunneling assignments are executed within all market sectors, including:

- Transportation (rail, highway, aviation)
- Environment
- Water/Wastewater (utilities and conveyance)
- Mining (access adits and mines)

Michael Schultz, PE | SchultzMS@cdmsmith.com | 617-453-6399
Mahmood Khwaja, PE | KhwajaM@cdmsmith.com | 617-452-6391

CDM Smith
cdmsmith.com

Colorado School of Mines

underground.mines.edu

The Center for Underground Construction and Tunneling at Colorado School of Mines, aka Underground at Mines, is a community comprised of collaborative, interdisciplinary faculty and students with a collective interest in education and research, within underground science and engineering. With a mission of advancing knowledge and developing leaders, many experts, researchers and students are united across disciplines: civil engineering, geology and geological engineering, mining engineering and mechanical engineering, as well as geophysics and computer science.

Mines is a public university focused on science and engineering, dedicated to educating and inspiring students, advancing knowledge and innovating to address the great challenges societies face today—particularly those related to the Earth, energy and the environment. Founded in 1874 with specialties in mining and metallurgy, Mines' scope and mission has expanded to meet the needs of industry and society, producing distinctive graduates and revolutionary innovations, and becoming a world leader in advancing sustainable use of the Earth's resources.

Mines has a long-standing tradition of hosting world-class short courses on our beautiful campus in scenic Golden, Colorado. Short courses combine classroom instruction with hands-on labs and demonstrations, creating unique opportunities to learn, network and earn CEUs. Short courses also present a unique opportunity to learn from the most experienced and innovative talent in the tunneling industry for both seasoned professionals and those new to the field.

Underground at Mines short courses are designed for industry professionals. With new discoveries consistently leading to exciting breakthroughs, ours is an industry with an almost unparalleled opportunity for innovation. While this is technically a "short course," it's one that's been thoughtfully designed to cover a broad range of the most relevant industry topics in as short a time as possible. In this way, Underground at Mines can be sure to offer you an efficient learning experience developed to help you get where you want to go — faster.

GROUTING AND GROUND IMPROVEMENT COURSE

MAY 13-16, 2019
GOLDEN, COLORADO

COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

Our short course presents a unique opportunity to learn from the most experienced and innovative talent in the tunneling industry. This is a 3.5 day course that covers engineering, equipment, materials and methods for grouting and ground modification used in civil and geotechnical engineering, underground construction, tunneling and mining.

Don't miss this opportunity for professional development and high-level networking — all while earning 2.4 CEUs!

Hands-on labs and workshops will give you the real-world experience you need to elevate your skillset and take your place at the cutting edge of the field. Learn more at **underground.mines.edu**.

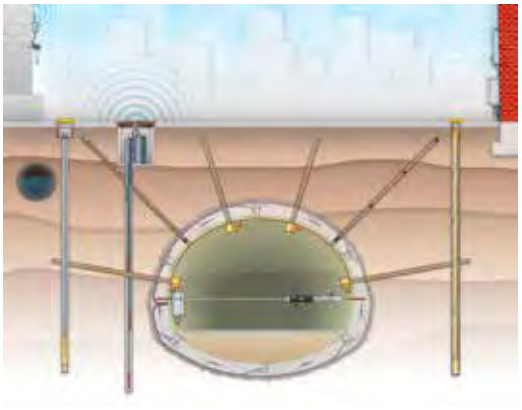
Geokon

GEOKON is a recognized world leader in geotechnical instrumentation. Founded in 1979, the company offers a full complement of products for a wide range of applications including tunnels, dams, mines, piles, pipelines, embankments, foundations, landfills, bridges and wind turbines. GEOKON's worldwide network of over 45 agencies distribute globally to North and South America, Europe, the Middle East, China, Russia, Asia Pacific and Australia/New Zealand.

With over 100 associates, GEOKON incorporates state-of-the-art manufacturing processes and equipment to produce the highest quality and performing products on the market. Geotechnical, mechanical, electrical and software engineering teams collaborate to develop the highly innovative, accurate and reliable instrumentation. As a result, GEOKON has been awarded ISO 9001:2015 registration from both ANSI•ANAB, USA and UKAS of Great Britain. GEOKON's calibration program complies with the ANSI/NCSL Z540-1 Calibration Laboratory and Measuring and Test Equipment General Requirements and all products have achieved Russian GOST certification for safety.

Specific for the tunnel and tunneling industries, GEOKON offers a full range of instrumentation including:

- NATM-style pressure cells
- Convergence meters
- Tape extensometers
- Multiple-point borehole extensometers
- Instrumented rock bolts
- Piezometers



- Strain gages
- Load cells
- Inclinometers and tiltmeters
- Crackmeters
- Settlement systems
- Dataloggers and Web-based software

All products are backed with a full 13-month warranty and supported by an experienced team of factory-trained associates ready to assist in instrument design, selection and installation. For more information, please visit www.geokon.com, email us at info@geokon.com or call +1-603-448-1562.

Geokon
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Web: www.geokon.com

Premier Pipe Systems Manufacturer for Over 90 Years

Since 1925, Naylor Pipe Company has been the premier manufacturer of Spiralweld pipe systems.

Naylor Spiralweld is available in diameters from 4" through 96" and wall thickness from 14 Ga. through 1/2" wall. The Spiralweld pipe is complemented with all types of fittings, fabrications to specification, and joint connections, including the exclusive Naylor Wedgelock Coupling, to complete your pipe system.

Naylor Spiral Buttweld pipe features two welds along the spiral seam. This creates a pipe structure in which the weld is as strong or stronger than the parent metal.

The Naylor manufacturing process creates a pipe that maintains an accurate diameter throughout its length. The uniformity of the pipe ends speed connection, whether mechanically coupled or welded.

Uniform wall thickness is assured because tolerances of steel strip are governed by the standards established by the American Iron and Steel Institute. In addition, the pipe is furnished in any required length with a cutting tolerance of plus or minus 1/8". In addition to carbon steel, spiralweld pipe can be formed from many steel grades, including abrasion resistant, weathering (A-588) and stainless.

Every length of Naylor Pipe is inspected and where required hydrostatically tested to applicable ASTM specifications. The pipe is available in lighter weights than other pipe making it possible

to save money, not only on initial cost, but also in transportation, handling and installation. By sizing the diameter of the pipe to the exact requirements, with exact lengths and factory-sized ends, the greatest economies can be realized.

Quotations are immediately available on inquiry.

Naylor Pipe Company
1270 East 92nd Street
Chicago, IL 60619 USA
Tel: 1-773-721-9400 Fax: 1-773-721-9494
Email: sales@naylorpipe.com
www.naylorpipe.com

Drill Tech Drilling & Shoring, Inc.

Drill Tech Drilling & Shoring, Inc. is a recognized leader in the foundation and excavation industry in the United States. The same guiding principles that helped Drill Tech become a top 10 Foundation Contractor, according to ENR's Top Specialty Contractors, can be seen in Drill Tech's Mining & Tunneling Division (DTM&T).

On the Barrick Range Front Declines, DTM&T has almost completed over 18,000 feet of twin declines almost six months ahead of schedule. Rock conditions varied in strength along the decline and while the contract was initiated using Roadheader excavation methods, DTM&T has utilized both drill & blast and roadheader techniques to overcome these varied rock strengths. Throughout the execution of the work, DTM&T focused on building a safe project ahead of schedule that met the quality expectations of Barrick. Drill Tech's efforts were recognized by Barrick and additional work was issued to Drill Tech's contract.

In addition to the twin declines, DTM&T performed contract work for other contractors on the project site that included Mass Excavation of 129,314 CY of rock and the application of 15,995 CY of shotcrete. During the course of these projects, DTM&T has performed safely for 814 days.

For more information, please visit www.drilltechdrilling.com, email us at dtds@drilltechdrilling.com or call at 925.978.2060
Drill Tech Drilling & Shoring, Inc.
2200 Wymore Way
Antioch, CA 94509

Industry leaders. Delivering innovative solutions.

Parsons is a technology-driven engineering services firm with more than 70 years of experience in the engineering, construction, technical, and professional services industries. The corporation is a leader in many diversified markets with a focus on infrastructure, defense, and construction. Parsons delivers design/design-build, program/construction management, systems design/engineering, cyber/converged security, and other professional services packaged in innovative alternative delivery methods to federal, regional, and local government agencies, as well as to private industrial customers worldwide.

We have successfully delivered some of the largest and most complex tunneling and underground construction projects in the world. From planning and design through construction management and operations, Parsons provides a complete range of services for water, wastewater, and transportation tunnels. Whether your project involves soft ground, rock, or mixed-faced conditions, our dedicated staff of more than 100 tunnel professionals have the experience and skills to manage the risks and deliver safe, economical, and innovative solutions. Our recent award-winning projects, such as Lake Mead Intake No. 3 and the Sheikh Zayed Road and Tunnel, demonstrate Parsons' position as an industry leader and our dedication to delivering on challenging projects.

Learn more at parsons.com.

parsons.com

Parsons PLUS envision more SM

Mining Equipment Ltd.

Mining Equipment Rolling Stock for Columbus, Ohio

"Rolling for more than 35 years"

Mining Equipment continues to supply the tunneling and mining industries with top-quality rolling stock, Jetair fans and steel ventilation ducting, as well as a large inventory of rebuilt equipment such as scooptrams, trucks, drill jumbos and other underground gear.

Mining Equipment is based in Durango, Colorado, with a main shop facility in Farmington, New Mexico. They also have steel fabrication capabilities near Shanghai.

Mine Hoists International, a sister company of Mining Equipment, is based in North Bay, Ontario. They boast the world's largest inventory of used mine hoist and large capacity stage winches for mining and shaft sinking projects. Their new 20,000 square foot shop in North Bay, Ontario can handle the largest of hoist and winch rebuilds.

Mining Equipment 10 Ton Locomotives for Columbus, Ohio

Normet

Our value proposition:
Defining the Future Underground.

The underground future consists of three main pillars, which highlight our expertise and focus:

1. Securing a safe future – adopting safe & sustainable solutions for all underground operations to build the safest places underground
2. Innovating for Performance – providing the best process understanding & productivity
3. Partnering for the Future – co-developing with our customers solutions to fulfil the business needs

Normet encourages a strong collaboration with its customers. We have amassed process expertise over thousands of mines and tunnel projects all over (and under) the globe. The broad perspective means experience and expertise about what should and should not be done to achieve the optimum results. Normet improves underground mining and tunnelling processes with knowledge and technology translating process expertise into actions and financial results.

Normet has a broad underground offering:

- Equipment for concrete spraying and transport, explosives charging, scaling, lifting, installation works, and logistics.
- Construction chemicals for sprayed concrete, admixtures for all types concrete, injection systems for rock improvement, reinforcement systems for high deformation conditions, spray applied waterproofing systems and needed chemicals for Tunnel Boring Machine (TBM) technology covering hard rock, Earth Pressure Balance (EPB), open face and slurry type machines.
- High quality and innovative rock reinforcement products that reduce the risk and consequences of accidents and facilitate high productivity in challenging rock conditions.
- Services for underground mining and tunnelling, including for example spare parts, rental equipment, equipment refurbishment, performance and field services.

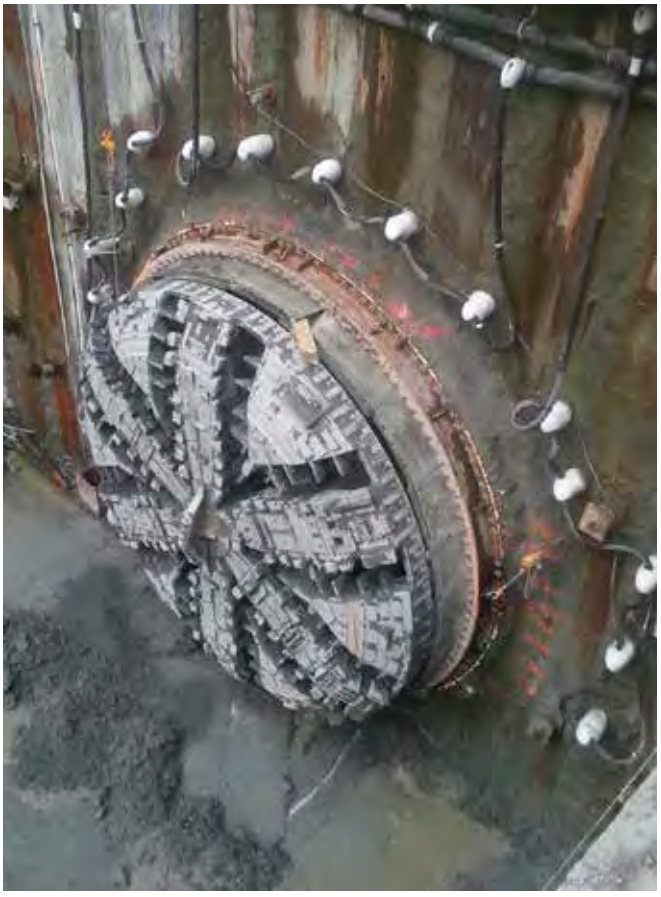
For further information, please visit us at: normet.com

SoilFreeze, Inc.

Soilfreeze Inc. is the largest U.S. contractor specializing in ground freezing for the construction industry. For nearly two decades, SoilFreeze Inc. has successfully completed scores of complex and technically challenging excavation support projects throughout the U.S.

We serve both the private and public sectors and have a substantial list of successful projects and satisfied clients. SoilFreeze has advanced and refined freeze technology to create freeze systems that are mobile, reusable, and expandable to address the needs of small projects and urban locations.

For further information, please visit us at: soilfreeze.com



SoilFreeze
ENGINEERING SOLID GROUND

THE INDUSTRY LEADER IN FROZEN SOIL TECHNOLOGIES

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- Environmentally Friendly

INDUSTRIES SERVED

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- Mining

APPLIED INNOVATION. PROVEN SOLUTIONS.

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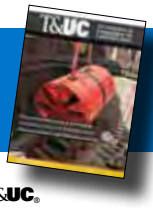
David R. Klug & Associates, Inc.

David R. Klug & Associates, Inc. provides international and national manufacturers representative services to the underground heavy civil and mine construction industries. The company specializes in the sale and coordination of specialty products, equipment and services for soft ground, conventional and NATM/SEM tunneling practices. Expertise is offered in the supply of various componentry used in the manufacture of one pass precast segmental tunnel linings inclusive of EPDM gaskets, plastic and steel connectors, grout lifting assemblies and precision steel segment casting moulds plus final lining forming systems for C-I-P final lining applications. Through their distribution company, Klug Construction Systems, LLC offers GFRP rock bolts and soft-eyes, steel and synthetic fiber reinforcement, prefabricated welded wire fabric and rebar reinforcing panels plus specialty grout systems for various tunnel backfill grout requirements for highway, rail, subway, water and CSO tunnel construction applications.

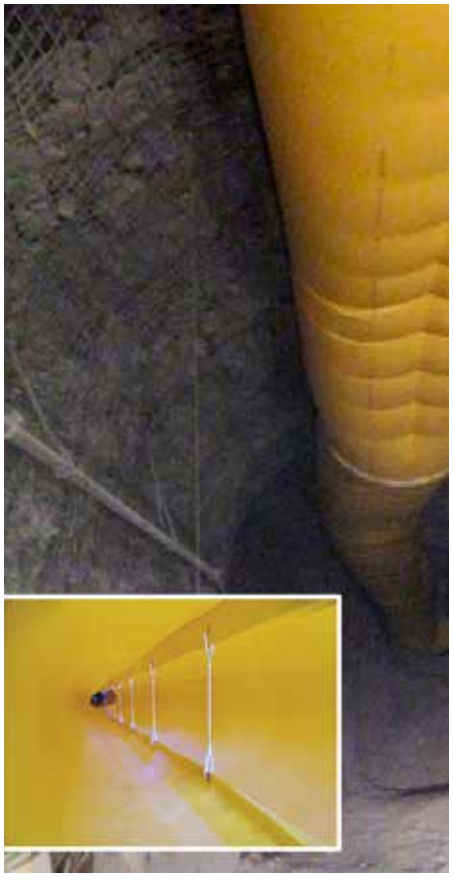
David R. Klug & Associates, Inc.
6000 Waterdam Plaza Dr, Ste 120
McMurray, PA 15317 USA
Phone: (724) 942-4670
Fax: (724) 942-4671
Email: information@drklug.com
Website: www.drklug.com



ABC Industries, Inc.

For over 90 years, ABC Industries continues to be a leading supplier of high quality, customized ducting solutions in many of the largest mine, tunnel and underground construction operations worldwide. ABC's complete line of layflat blower tubing, ducting, brattice, fly pads, blast curtains, fans and accessories offer a complete ventilation solution for underground professionals. As tunneling and underground construction continue to evolve, ABC proactively collaborates with industry professionals to engineer unique, premium ventilation products exceeding the needs of the industry.

Our featured MineVent® and TruOval MineVent® ducting products, with their welded construction, eliminate air loss and weakening associated with conventional sewn ducting. Our available RipStop substrate technology option prevents small tears from expanding into sizable holes. ABC's ducting also features several easy-to-handle accessories that are more cost-effective, require less space and smoothly transfer air through bends and turns. To view more of our innovative products, please visit our website at: **www.abc-industries.net.**



Northwest Laborers-Employers Training Trust – Safety and Hazard Awareness for Tunnels (SHAFT) program

The Safety and Hazard Awareness for Tunnels (SHAFT) program seeks to provide comprehensive safety training for both new and experienced tunnel professionals.

The curriculum (developed by the Northwest Laborers-Employers Training Trust with input from a team of industry experts and stakeholders) is comprised of a blend of classroom discussion and interactive use of materials and mockups. Classes focus on tunnel safety, rail, and utilities.

The training facility, located in Elma, Washington, features a TBM mockup, loci, and access to 1,400' of 12' diameter tunnel – providing students with a unique educational experience.

Northwest Laborers-Employers Training Trust
+1 (800) 240-9112 www.nwlett.org

You Can Count on Case

Case Foundation Company has extensive knowledge involved in the tunneling and underground construction industry. This experience extends to various tunneling and underground applications such as:

- Traffic Tunnels
- CSO Tunnels
- Subway Tunnels
- Outfall Tunnels
- Airport Tunnels

Typical applications have been the installation of support of excavation systems for large diameter access shafts, retrieval shafts or vent shafts for both temporary and final design applications. It is typically accomplished using secant piles, auger cast piles or a combination of both. Similar procedures have also been employed on cut and cover tunnels.

We also have installed shafts up to 15 feet in diameter in both soil and rock using full face drilling tools for access shafts for micro tunneling projects and vent shafts for various tunnel applications.

Case Foundation Company
1325 West Lake Street
Roselle, IL 60172
800-999-4087
www.casefoundation.com

Gall Zeidler Consultants

Gall Zeidler Consultants (GZ) is a worldwide leader in geotechnics, tunnel design and engineering, and tunnel construction management, with special expertise in transportation and infrastructure projects. GZ offers exceptional expertise in urban tunneling with shallow overburden and the related protection of neighboring structures and surface operations by innovatively combining conventional (SEM / NATM) and mechanical tunneling methods (TBM) with ground improvement and state-of-the-art waterproofing techniques.

The company specializes in mastering difficult ground conditions by using cutting-edge ground improvement methods such as dewatering, grouting, and ground freezing. GZ employs over 50 staff worldwide, and has a history of over 170 miles (275 kilometers) of successfully completed international tunneling projects. The company's expertise has consistently been sought after by major contractors and project owners in the industry developing tailored tunnel solutions and to assist with the mitigation of risks associated with tunneling.

GZ's ongoing projects include East Side Access, New York, Northgate Link Extension, Seattle, Crossrail, London and Riyadh Metro. GZ was involved in the recently completed Caldecott Tunnel Fourth Bore and Devil's Slide Tunnels in California, Dulles Metrorail Extension, Washington, D.C., Cable Tunnels in London and Singapore and multiple underground station upgrades in London.

Brookville

BROOKVILLE 27-Ton MSHA Permissible Locomotives Boosting Safe Work Environment at Major Los Angeles Tunneling Project

Brookville Equipment Corporation (BROOKVILLE) recently shipped three 27-ton MSHA-permissible tunneling locomotives to the Walsh-Shea Corridor Constructors for use on the Crenshaw/LAX Transit Corridor Tunnel Project in Los Angeles. By design, the locomotives reduce the risk of explosion due to geological conditions that may host the presence of methane and other combustible gases. Cal-OSHA has classified the tunnel drives on this project "gassy", mandating the use of MSHA permissible locomotives.

The 27-ton locomotives' special safety features include air start, an enclosed engine block, an exhaust filtration system, wiring and piping guards, and an intake flame arrestor, among other upgrades, to fully comply with MSHA's permissibility requirements. Featuring an 8.3L Cummins six-cylinder diesel engine and four-speed transmission, the 185-horsepower locomotives operate on 36-inch rail gauge underground for Walsh-Shea Corridor Constructors .

"BROOKVILLE was selected based on past performance, simplicity of operation and diagnostics, their ability to communicate locally with MSHA, and knowing we would be dealing with the good people of Brookville, PA, U.S.A," said Walsh-Shea Corridor Constructors Tunnel Construction Manager David Girard, P.E.

Bradshaw Offers Innovative Tunnel Engineering and Construction Technology

Bradshaw Construction Corporation strives to apply the most appropriate tunneling technology to each project based on its purpose, subsurface conditions and surface restrictions. The company's management team is proud of its ability to construct any type of tunnel in any soil condition both above and below the water table. From small hand mined, wood-box and liner plate tunnels to large NATM shotcrete-lined tunnels; from small pilot tube guided auger bores to large rib-and-board shield and tunnel boring machine (TBM) tunnels; from conventional pipe jacking to slurry microtunneling (MTBM) to earth pressure balance (EPB) TBM tunnels; and from hand mined drill and blast to rock tunnel boring machines (TBMs), Bradshaw Construction has a solution.

For your next project, let our knowledgeable staff of tunnel engineers and construction professionals create the most cost effective, safest, and highest quality solution for your unique tunneling needs.

Bradshaw Construction Corporation
175 West Liberty Road
Eldersburg, MD 21784 USA
Telephone: +1-410-970-8300
Fax: +1-410-970-8340
www.bradshawcc.com

Rock Splitting Technologies

The N50 Power Splitter uses a feather and wedge system. Hanging from an excavator, the N50 uses the existing excavator hydraulics to push the wedge between the feathers exerting a force in excess of 2,700 tons! The Rock Splitter's wedge requires a pre-drilled 4" hole that is 4.3 feet to 5 feet deep. The wedge travels 700mm or 2.3 feet into the hole. The breaking of rock or concrete will happen immediately. RST also distributes the K25 hand held splitter.

- Splitter uses 21 MPa working pressure, which can be supplied by most excavators, creating a splitting pressure in excess of 2,700 tons.
- Equipped with relief valves to help prevent too much pressure and damaging the splitter.
- Equipped with pressure gauge for easy maintenance.
- Easy to replace wedge and counter-wedges.
- Attaches to Excavators and can be hung from a crane for shaft work.
- No vibration, quiet and simple to use!

Rock Splitting Technologies, Inc.
2393 Canton Hwy, Suite 400
Cumming, GA 30040
Office: (770) 886-4711
Sales@RockSplittingTech.com
www.RockSplittingTech.com

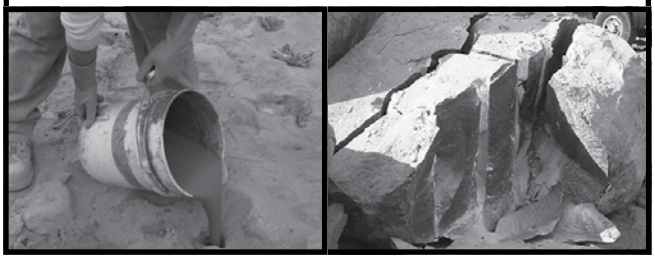
McMillen Jacobs Associates

McMillen Jacobs Associates provides technical engineering design and construction expertise in the conveyance (water, wastewater, stormwater), dispute resolution, energy and power, transportation, transit, underground, and water resources industries.

We offer a full range of design, design-build, self-performing construction and construction management services. We work closely with our clients at every stage of a project, assisting them with planning, design expertise, project management, construction, and start-up. Our 21 offices in North America and Australasia and more than 400 staff serve clients locally and worldwide.

McMILLEN
JACOBS
ASSOCIATES

Design with Vision, Build with Integrity
www.mcmjac.com



Dā-mite Rock Splitting Mortar from the Daigh Company, Inc.

Daigh Co. is the supplier of Dā-mite Rock Splitting Mortar. Dā-mite is used to fracture rock and concrete in "no-blast" conditions. Dā-mite is an ideal and effective tool for fracturing mass rock, boulders, trench rock, dimensional stone, concrete and reinforced concrete. "Dā-mite is mixed with water and placed in the appropriately placed predrilled holes, where it sets and expands, fracturing the rock/concrete". No license required. There are four grades of Dā-mite, providing enough versatility to be utilized in drilled hole diameters from 1 in. to 2 ¾ in.

Daigh Company, Inc.
2393 Canton Hwy., Ste. 400
Cumming, GA 30040
Telephone: +1-770-886-4711
Fax: +1-770-887-3783
Email: sales@daighcompany.com
www.daighcompany.com

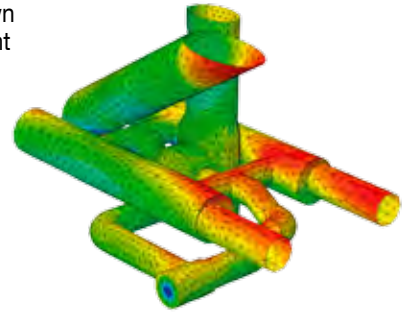
Dā-mite®
Rock Splitting Mortar

Dr. Sauer & Partners

Dr. Sauer & Partners is a specialist, independent consultancy providing the full range of design and construction management services for tunnels, shafts and caverns. Delivering innovative, cost-effective and environmentally aware designs, the company has over 30 years' experience providing solutions for some of the world's most challenging tunnelling projects for Metro, Highway, Water, Rail and Mining, for urban and rural tunnels in any type of geology.

Services delivered include initial consultation and feasibility studies, final design, supervision and construction management, tunnel inspection and condition surveys, rehabilitation, waterproofing and water control, geotechnical engineering, and mining support services.

Current and recent projects include: Chinatown Station (USA), Ottawa Light Railway (Canada), Bank Station Capacity Upgrade (UK), Crossrail (UK), Red Line (Israel) and Eglinton Crosstown LRT (Canada).



www.dr-sauer.com

PERSONAL NEWS

RORY BALL will lead Brierley Associates' new Cleveland, OH office as part of its Midwest expansion strategy. Ball has more than 14 years of domestic and international experience as a project leader and tunnel engineer. His North American and Pacific Rim tunnel experience encompasses subsurface conditions ranging from soft mud to extremely abrasive soil with abundant cobbles and boulders, to glacial till, to a variety of hard rock types. He has served as resident engineer, design lead and technical reviewer on a diverse portfolio of civil and tunneling projects, identifying solutions to provide cost effective and efficient designs for complex heavy civil and tunneling challenges. He has led office and field teams to proactively address project risks for public and private clients.


BALL

ED CARTER has joined Moretrench, a Hayward Baker company, as its new Groundwater Treatment Division manager. Carter has operational and technical experience in the ground water/environmental treatment industries. Under his leadership, Moretrench will continue to provide turnkey water treatment service to go hand-in-hand with its dewatering and geotechnical construction services.


CARTER

Millen Jacobs Associates has announced that **RENÉE FIPPIN** is the recipient of the 2018 James Wilton Award. She is currently project manager for the San Francisco Public Utilities Commission's Mountain Tunnel Improvement Project. There, she manages a team of 16 subconsultants and more than 50 staff from the Bay Area and other McMillen Jacobs offices. She is a licensed civil engineer and geotechnical engineer in California and has 20 years of geotechnical and structural engineering experience, the last 11 with McMillen Jacobs. Fippin is known for her technical abilities on owner and contractor design assignments, a tireless dedication and ability to manage large teams and mentor junior staff, a talent for keeping clients satisfied, and a solid business and business development sense.


FIPPIN

The James Wilton Award honors the memory of James Wilton, former principal and president of Jacobs Associates, and recognizes the accomplishments and contributions made by employees of McMillen Jacobs Associates. ■

PRODUCTS

Boart Longyear debuts new DriftMaster top hammer rods

Boart Longyear has launched its newest top hammer tooling, the DriftMaster series of rods and bits. DriftMaster rods and bits are designed with a unique thread profile for added endurance and strength in the most demanding tunneling, bolting and drifting applications.

The new series offers increased strength through stress reduction in two ways — the tapered profile provides an increased material cross-section at the base of the threads and the asymmetric thread geometry minimizes stress concentrations. The lower stress combined with deep case hardening allows for a significant increase in cyclic load handling capability. More load cycles means more drilling time and more productivity. Optimizing the load distribution and contact area, the thread geometry is designed to maximize resistance to wear. And, combined with the wear resistance associated with carburizing heat treatment, the DriftMaster endures the toughest drilling conditions.

"Global field testing of DriftMaster products has exceeded expectations leading to an extended trial duration, extensive sample size and very positive responses." said Jeff Hogan, product manager for Top Hammer Tooling at Boart Longyear. "Test results from the field strongly aligned with our design goals of significantly improved durability compared to standard threads."

DriftMaster is being introduced in 35 mm (1.4 in.) hex cross-sections for use with standard, Retrac, and Straightrac button bits from 43 mm-64 mm. The initial offering includes dome and pilot reamers — including optional RazorBack, a patented high-productivity back-reaming bit. ■


The DriftMaster series of rods and bits can be used in tunneling, bolting and drifting applications.

www.boartlongyear.com

COMPILED BY JONATHAN KLUG, DAVID R. KLUG & ASSOCIATES

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark	NJ	Subway	14,600	24.5	2021	Design study
2nd Ave. Phase 2	NYC-MTA	New York	NY	Subway	16,000	20	2021	Under design
2nd Ave. Phase 3-4	NYC-MTA	New York	NY	Subway	89,600	20	2022-27	Under study
Kensico-Eastview Connection Tunnel	NYC-DEP	New York	NY	Water	10,500	27	2024	Under study
Flushing Bay CSO	NYC_DEP	New York	NY	CSO	13,200	20	2026	Under study
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Rail	25,000	30	2022	Under study
Redundancy Tunnel Program - Northern	Boston MRWA	Boston	MA	CSO	23,760	10	2026	Under study
Redundancy Tunnel Program - Southern	Boston MRWA	Boston	MA	CSO	50,160	10	2028	Under study
Narragansett Bay CSO Phase III - Pawtucket Tunnel Conveyance Tunnel	Narragansett Bay Commission	Providence	RI	CSO	13,000 8,800	28 10	2020 2024	Under design Under design
Amtrak B&P Tunnel	Amtrak	Baltimore	MD	Rail	40,000	32	2021	Awaiting funding
Hampton Roads Bridge-Tunnel Project	Virginia DOT	Hampton Roads	VA	Highway	7,500	42	2018	Shortlist announced
Alex Renew Long-Term Control Plan	City of Alexendria	Alexandria	VA	CSO	10,500	20	2019	Under study
Potomac River CSO Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	24,000	18	2022	Under design
Superconducting Maglev Project - Northeast Corridor	TNEM/BWRR	Washington	DC	Rail	146,520	43	2020	Under design
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2019	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2019 2020	Under design Under design
Westerly Main Storage Tunnel	NEORSD	Cleveland	OH	CSO	12,300	24	2018	JayDee/ Obayashi awarded
Shoreline Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,100	21	2021	Under design
Shoreline Consolidation Tunnel	NEORSD	Cleveland	OH	CSO	11,700	9.5	2021	Under design
ALCOSAN CSO Ohio River Allegheny River Monongahela River	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	10,000 41,700 53,900	30 30 30	2021 2022 2023	Under design Under design Under design
I-75 modernization project	Michigan DOT	Detroit	MI	CSO	22,000	14	2018	Oakland Corridor awarded
Enbridge Line 5 Tunnel	Enbridge	Traverse City	MI	Oil	23,760	12	2020	Under study
I-70 Floyd Hill Highway Tunnel	Colorado Dept. of Transportation	Denver	CO	Highway	15,840	60x25	2022	Under design

To have your major tunnel project added to the Tunnel Demand Forecast, or to update information on a listed project, please contact Jonathan Klug at jklug@drklug.com.

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
W-6: Highway 90 to SW Military Drive	San Antonio Water Systems	San Antanio	TX	Sewer	28,000	10	2020	Under design
D2 Subway - 2nd Light Rail Alignment	Dallas Area Rapid Transit	Dallas	TX	Highway	3,000	22	2020	Under design
Ship Canal Water Quality Project	Seattle Public Utilities	Seattle	WA	CSO	14,250	19	2018	Under design
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	Transit	10,500	18	2022	Under design
L.A. Metro Westside Phase 2 Phase 3	Los Angeles MTA	Los Angeles	CA	Subway	 26,500 26,500	 20 20	 2016 2018	Tutor Perini/O&G JV awarded Frontier-Kemper/ Tutor/Perini awarded
Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2020	Under study
Northeast Interceptor Sewer 2A	LA Dept. of Water and Power	Los Angeles	CA	Sewer	18,500	18	2018	Delayed indefinitely
River Supply Conduit - Unit 7	LA Dept. of Water and Power	Los Angeles	CA	Water	13,500	12	2018	Frontier-Kemper awarded
JWPCP Effluent Outfall Tunnel project	Sanitation Districts of LA	Los Angeles	CA	Sewer	37,000	18	2018	Dragados USA low bidder
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2021	Under design
BDCP Tunnel #1 BDCP Tunnel # 2	Bay Delta Conservation Plan	Sacramento	CA	Water	26,000 369,600	29 35	2018 2019	Under design Under design
SVRT BART	Santa Clara Valley Trans Authority	San Jose	CA	Subway	22,700	20	2019	Single tunnel option approved
Silicon Valley Clean Water Tunnel	Silicon Valley Clean Water	Silicon Valley	CA	CSO	17,500	13	2018	Barnard/Bassac JV awarded
California Waterfix 1 California Waterfix 2	Delta Conveyance Design and Const.	Sacramento	CA	Water	39,905 403,400	28 40	2020 2020	Under design Under design
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2018	JayDee/Michels/C&M McNally awarded
Ashbridges Bay Outfall Tunnel	Metrolinx	City of Toronto	ON	CSO	11,500	23	2018	Southland/Astaldi JV Awarded
Yonge St. Extension	Toronto Transit	Toronto	ON	Subway	15,000	18	2016	Under study
Taylor Massey Tunnel	City of Toronto	Toronto	ON	CSO	20,000	18	2018	Under design
Inner Harbour West	City of Toronto	Toronto	ON	CSO	18,400	19	2021	Under design
Scarborough Rapid Transit Extension	Toronto Transit Commission	Toronto	ON	Subway	25,000	18	2018	Under design
REM Transit Tunnel	City of Montreal	Montreal	QC	Subway	27,000	22	2017	SNC/Dragados/ Aecon JV Awarded
Green Line LRT	City of Calgary	Calgary	AB	Transit	26,250	20	2018	Under design
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Traylor/Aecon JV awarded
Annacis Island Outfall	City of Vancouver	Vancouver	BC	Water	8,000	10	2017	Awaiting award
Broadway Sky train	Trans Link	Vancouver	BC	Subway	25,000	18	18	Under design
Northern Gateway Hoult Tunnel	Enbridge Northern	Kitimat	BC	Oil	23,000	20	2014	Under design

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