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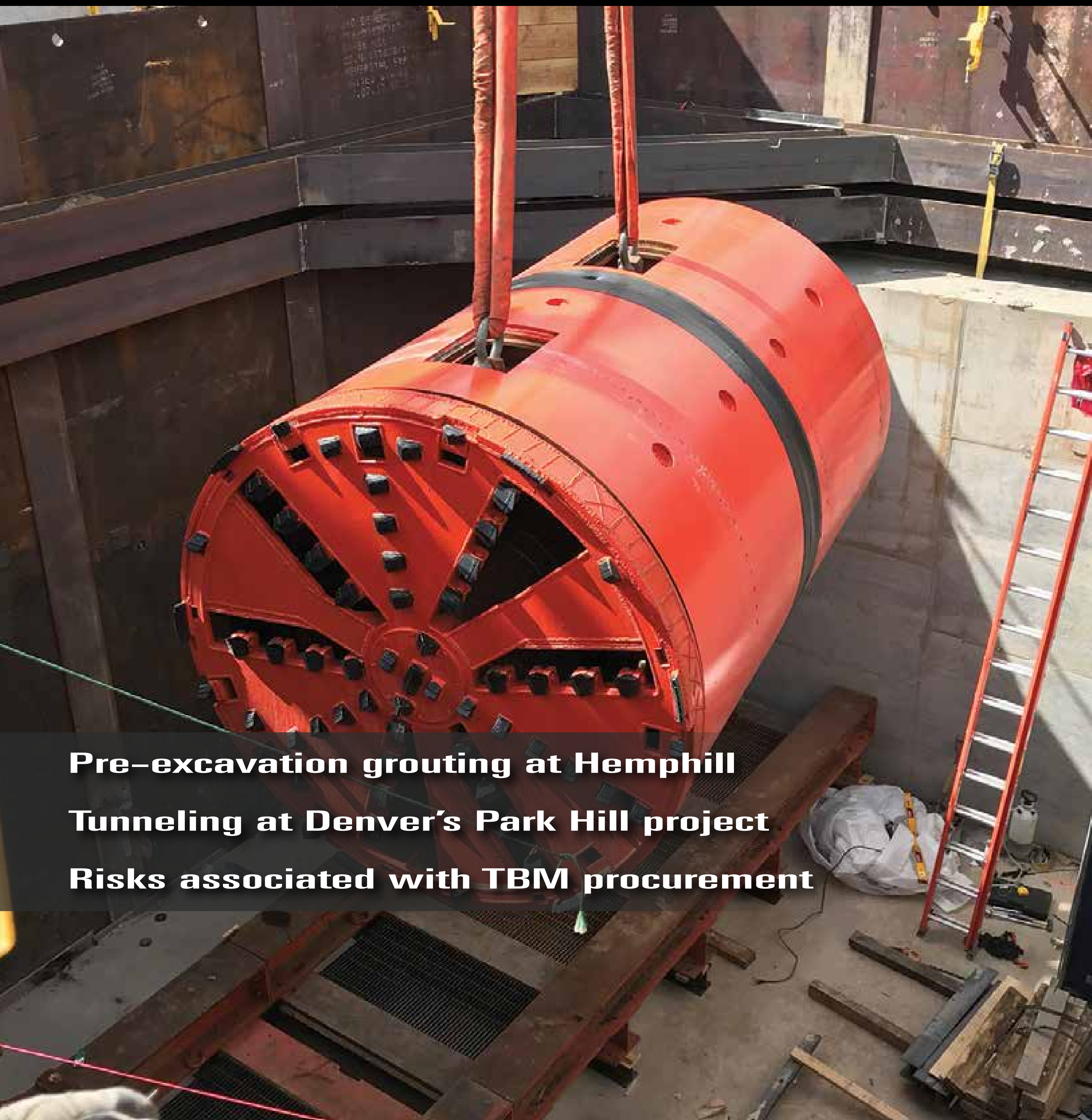

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COVER STORY

In this issue — The population of Denver, CO has grown to more than 700,000. The city's storm water drainage system was put in place in the early 1900s and has not been replaced. Denver has embarked on a four-phase, $298-million project to replace parts of the system. T&UC's William Gleason has the story. Cover photo courtesy of Kyle Friedman, Brierley Associates.

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DEPARTMENTS

CHAIRMAN'S COLUMN

Looking back at NAT 2018 and ahead to Cutting Edge

Many of you were among the nearly 1,200 attendees of the North American Tunneling Conference in Washington, D.C., June 24-27. For those who couldn't make it, I'll give you a brief recap.

Right from the start, there were events designed to draw in early arrivals. Sunday, June 24 featured two well-attended short courses covering precast segments and all aspects of underground grouting. Also conducted on Sunday was the "Recommended Contract Practices for Underground Construction" workshop, providing a unique opportunity for conference attendees to participate in the updating of the 2008 publication. Members of the audience were invited to provide comments regarding the content of all 13 chapters.

Monday morning's keynote speaker was Deputy Architect of the Capital, Christine Merdon. Merdon gave a fascinating and locally topical presentation on the recently completed Capital Dome restoration project. It was quite entertaining to see a room full of tunnelers looking up for a change.

As expected, the breadth and depth of the 20 technical sessions were the conference's main draw – in spite of competing with the soccer World Cup on six TVs in the lobby bar.

This year's NAT conference offered three specialty networking events: Owners' Reception, UCA Young Members Networking event and the Women in Tunneling event. Each was very well-attended. Additionally, kick-off workshops for our Teach the Professors program were conducted during the conference.

Sponsorships for the conference exceeded that of the previous four NAT conferences – combined. Thank you to all of our sponsors. Your generosity will allow the UCA of SME to continue awarding dozens of annual scholarships.

Next up is the seventh edition of the Cutting Edge Conference in Atlanta, GA, Oct. 29-31. This year's theme is "Advances in Tunneling Technology." Six technical sessions and two panel discussions will be featured. A visit to the City of Atlanta Water Supply Program site is also being offered. Upon completion, this $347 million project will extend the city's raw water storage capacity from the current three days to more than 30 days. Project elements include 8 km (5 miles) of tunnel boring machine-driven tunnel in rock and 11 shafts of various diameters and depths. The old rock quarry in which the tunnel drive is staging will be converted into a 9.1-billion L (2.4-billion gal) water storage facility, with the surrounding area being converted to a public park.

In addition to the Cutting Edge Conference, the UCA Young Members are looking for speakers for their webinars. This is one of the most effective ways to educate and mentor our next generation of tunneling professionals. If you have technical expertise in a particular subject or a great story to share, please contact me and I'll put you in touch with our UCAYM group. ■

Mike Roach,
UCA of SME Chairman

New York City announces plans for $1.2-billion tunneling project in Westchester County

The New York City Department of Environmental Protection (DEP) announced plans for a $1.2-billion tunneling project that will improve operational flexibility among the facilities that are vital to the drinking water supply for more than nine million people in the city and Westchester County. The public works project will be New York City's largest water-supply tunneling effort in Westchester County since the 1940s, and its construction will create hundreds of jobs for local laborers. Construction on the first elements of the project is expected to start in approximately five years.

The centerpiece of the project — known as the Kensico-Eastview Connection (KEC) — will be a 3.2-km (2-mile) long tunnel between Kensico Reservoir and the Catskill-Delaware Ultraviolet Light Disinfection Facility in Eastview. The new aqueduct will provide an additional conveyance between these vital components of the water supply, giving DEP the ability to take other facilities out of service for periodic maintenance and inspection.

"The Kensico-Eastview Connection is a critical investment in the long-term resiliency of New York City's water supply system," DEP commissioner Vincent Sapienza said in a statement. "By providing an additional connection between Kensico Reservoir and our treatment facilities to the south, this new tunnel will further guarantee the reliable delivery of water to New York City and population centers in Westchester County, including New Rochelle, White Plains and Yonkers. We look forward to working with our neighbors in Westchester County to ensure that the city's waterworks continue to supply high-quality drinking water to more than 9.6 million New Yorkers every day."

"This is an example of how government can work effectively when we all work together," Westchester County executive George Latimer said. "Westchester has long enjoyed some of the best drinking water in the country and this is an important step to make sure future generations will enjoy fresh, clean water. Along with preserving this great resource, I am also pleased to see that this project will create local jobs while providing helpful redundancy to the infrastructure that our communities depend on. This is a 'win-win' for all involved."

"We are looking forward to working with DEP on this very valuable project, which will benefit the entire region," Mt. Pleasant Supervisor Carl Fulgenzi said. "As we have for decades, our town will work closely with managers of the New York City water supply to ensure this tunneling project happens smoothly, efficiently, and safely."

"This project is a classic win-win," state Sen. Terrence Murphy said. "It will make vital improvements to our infrastructure while creating good jobs for local workers."

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Euclid Creek Tunnel will begin protecting Lake Erie from untreated discharges

On July 13, the 4.8-km (3-mile) long Euclid Creek combined sewage overflow tunnel in Ohio came online and began accepting flows. The tunnel is the first in a series of storage tunnels that are part of the $3 billion effort known as Project Clean Lake.

Project Clean Lake is a 25-year project that will drastically reduce the amount of combined sewage entering local waterways, including Lake Erie, from Cleveland, OH each year.

Project Clean Lake calls for the construction of seven underground tunnels, some 5 to 8 km (3 to 5 miles) in length, that will be used to store storm water and sewage during a heavy rain event until it can be pumped out, cleaned and released into the lake.

During the 1970s, an estimated nine billion gallons of untreated water would flow into Lake Erie during heavy rains. And even though it was able to reduce that to 4.5 billion gallons, Cleveland was still found to violate the federal Clean Water Act. Cleveland was mandated to come up with a solution. Project Clean Lake will eventually take that to less than a half-billion gallons a year, *News 5 Cleveland* reported.

In July, the 4.8-km (3-mile) long Euclid Creek tunnel project that started construction in 2011 officially came online.

"It began accepting flows on July 13, so we've had a couple of smallish rain events that have gone through but we've been able to capture all the flows," said Jennifer Elting of the Northeast Ohio Regional Sewer District.

In the fall of last year, construction began on the Doan Valley tunnel project under University Circle.

"This project will focus mainly on overflow points that currently overflow into Doan Brook. There's about 11 of them right now," Elting said. "So we'll be able to have a much healthier, much cleaner Doan Brook, capture that combined sewage and eventually send it to the Easterly Wastewater Treatment Plant for full treatment." ■

Scotland's largest storm water tunnel is now operational

A two-year, £100 million sewer project beneath the city of Glasgow, Scotland has been completed and is now operational.

The *BBC* reported that construction of the Shieldhall Tunnel involved 100 workers and that it is the largest waste water tunnel in Scotland, with a 4.8-km (3.1-mile) underground channel from Craigton to Queen's Park in the south of the city.

Scottish Water hopes the new sewer will improve water quality in the River Clyde and tackle flooding.

Roseanna Cunningham, the environment secretary, performed the official switch-on two years after launching the tunnel boring machine (TBM).

She hailed the feat of engineering as extraordinary.

"The strategic importance of the Shieldhall Tunnel as part of the ongoing investment across Glasgow by Scottish Water cannot be understated," she said.

"It's a fantastic example of the capital investment program delivering real long-term benefits for communities to reduce flooding, help deal with the impact of climate change and improve the environment.

"Much of our underground infrastructure for water and waste water dates to the Victorian era when we proudly led the way in introducing massive improvements to deliver positive impact on the health of our communities."

Cunningham added: "Communities across Glasgow will benefit for years to come from this latest extraordinary feat of engineering which lies hidden deep beneath the city."

The tunnel was excavated using a state-of-the-art tunnel boring machine that weighs 1 kt (1,100 st), is longer than 14 buses and was named Daisy the Driller by a local schoolboy.

The tunnel will alleviate pressure on the existing waste water network with 90,000 m^3 (3.2 million cu ft) of extra storm water storage.

Its completion marks one of the most significant infrastructure projects in the city of Glasgow since Victorian times.

Douglas Millican, Scottish Water's chief executive, said: "The city's waste water infrastructure required major

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New York: Project expected to be done in 2035

(Continued from page 4)

"Clean drinking water is the lifeblood of our communities," state assembly member Tom Abinanti said. "We must modernize our systems to ensure that high-quality drinking water continues to flow when we turn on the tap."

The KEC project will include construction of the new tunnel, facilities to draw water from Kensico Reservoir and move water into the ultraviolet plant, and other infrastructure work. In 2017, DEP collected soil and bedrock samples from the area to support the design of the project, which has already begun. Work on the tunnel itself is expected to begin around 2025. DEP expects to finish the project around 2035.

The tunnel will stretch approximately 3.2 km (2 miles) from an intake chamber on the western side of Kensico Reservoir to a connection point at the ultraviolet disinfection facility. DEP expects the finished tunnel to measure approximately 8.3 m (27 ft) in diameter and run 122 to 152 m (400 to 500 ft) below ground. The tunnel will be large enough to carry a maximum of 9.8 billion L (2.6 billion gal) of water each day. Its design accounts for future growth in the city and Westchester County, the potential addition of treatment facilities, and the need to periodically take other aqueducts out of service for maintenance or inspection.

The project also includes new facilities and site work at Kensico Reservoir and the ultraviolet treatment plant. A century-old intake chamber at Kensico Reservoir will be upgraded and enlarged to draw water into the new tunnel. The reservoir's shoreline around that intake chamber will also be improved to prevent sediment from getting into the new tunnel. A new screen chamber to remove debris from the water will be constructed just north of DEP's main campus at the reservoir, near Columbus Avenue in Valhalla. An interconnection for the Town of Mount Pleasants' water supply will also be incorporated into the screen chamber. The chemical feed systems at Kensico Reservoir will be upgraded to provide the proper treatment of drinking water in the new tunnel and existing ones. The work at Kensico Reservoir will also include a range of grading, drainage, storm water and utility improvements. ■

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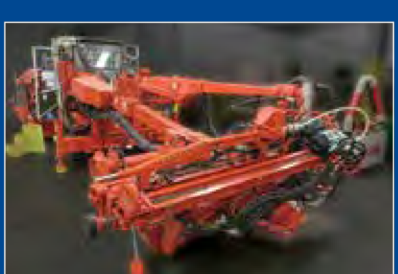

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Twin crossover tunnel boring machines to bore on Mumbai Metro Line 3

On June 11, 2018, a Robbins Crossover XRE destined for Line 3 of India's Mumbai Metro arrived in Mumbai port following a successful factory acceptance test in April. The machine, combining features of a hard-rock, single-shield tunnel boring machine (TBM) and an earth pressure balance machine (EPBM), is one of two 6.65-m (21.8-ft) crossover machines that will bore under contract UGC-01. Operation of these two machines will be carried out by Larsen & Toubro, part of

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The Robbins Crossover machines for the L&T-STEC JV were chosen due to variable geology with possible water pressures up to 2 bar.


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Mumbai: Mixed ground expected

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the Larsen & Toubro-Shanghai Tunnel Engineering Co. Joint Venture (L&T-STEC JV). The Robbins Company will provide key personnel for the initial boring phase. "During the factory acceptance testing, we observed that the machine and backup system are robust enough for hard rock tunneling," stated Palwinder Singh, head of tunnel operations for L&T-STEC JV.

During the bores, consisting of parallel 2.8-km (1.7-mile) long tunnels, geologic conditions will include mixed ground and possible water pressures up to 2 bar. According to Singh, "A crossover XRE was chosen because of the expected geology," which includes basalt rock and transition zones consisting of black carbonaceous shale, tuff and breccia. Rock strengths are anticipated to range between 15 and 125 MPa (2,200 and 18,100 psi) UCS. The machines will bore with only 15 to 20 m (50 to 70 ft) of cover above the tunnel and the structure will be lined with reinforced concrete segments in a 5+1 arrangement.

Robbins personnel inspect the backup system of the custom-designed Robbins XRE TBM during factory acceptance testing.

The metro tunnels will run between the Cuffe Parade Station and Hutatma Chowk station,

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Mumbai Metro: TBM launched in August 2018

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passing through the Vidhan Bhavan and Church Stations. Both crossover machines will be launched from the same 25-m (82-ft) deep by 22-m (72-ft) long shaft at the Cuffe Parade Station. "The limited length of the shaft requires running the TBMs for the first 100 m (328 ft) with some or all the back-up decks at the surface," said JP Bayart, Robbins project engineer. "The TBMs and backup systems are connected with umbilical cables and hoses."

The TBMs will begin their excavation in hard rock mode. "Each cutterhead is optimized for operation in rock, as this is what is expected. The machines can also operate in soft ground thanks to the screw conveyor with bulkhead gate and discharge gate," said Bayart. "The Robbins Torque-Shift System, consisting of two-speed shifting gearboxes coupled to the main drive motors, allows for the high cutterhead torque required for soft ground operation." The face of each machine is equipped with six muck buckets and six large internal muck loading plates. This design, in combination with the screw conveyor located at the centerline of each machine, will allow for the option of fully emptying the cutterhead chamber, resulting in minimal wear when EPB mode is not required. Muck will be removed from the tunnels via muck cars.

Assembly and launch preparations for the first XRE TBM began on June 20 and were estimated to take about six weeks. The second Robbins XRE TBM underwent factory acceptance testing at the end of May and was to arrive at the jobsite at the end of July for its assembly. "Our target is to achieve an average of 250 m (820 ft) of boring per month," said Jim Clark, Robbins projects manager India. "The target to complete the boring operations is 20 months, which includes the additional time required for the short startup using umbilicals on the initial drives, dragging the machines and relaunching through three stations." Contractor L&T plans to work crews on double shifts to cover a full day of operations in order to keep to this timeline. The machines will join two Robbins Slurry machines boring a separate contract of the Mumbai Metro Line 3. The first of those machines was launched in August 2018. The Metro Line 3 project as a whole is estimated to be completed by 2021. ■

T&UC NEWSNEWS

Scotland: Two-year project completed

(Continued from page 8)

improvements to help transform it into a modern, integrated and sustainable system that will improve the environment and biodiversity on the River Clyde and help tackle flooding.

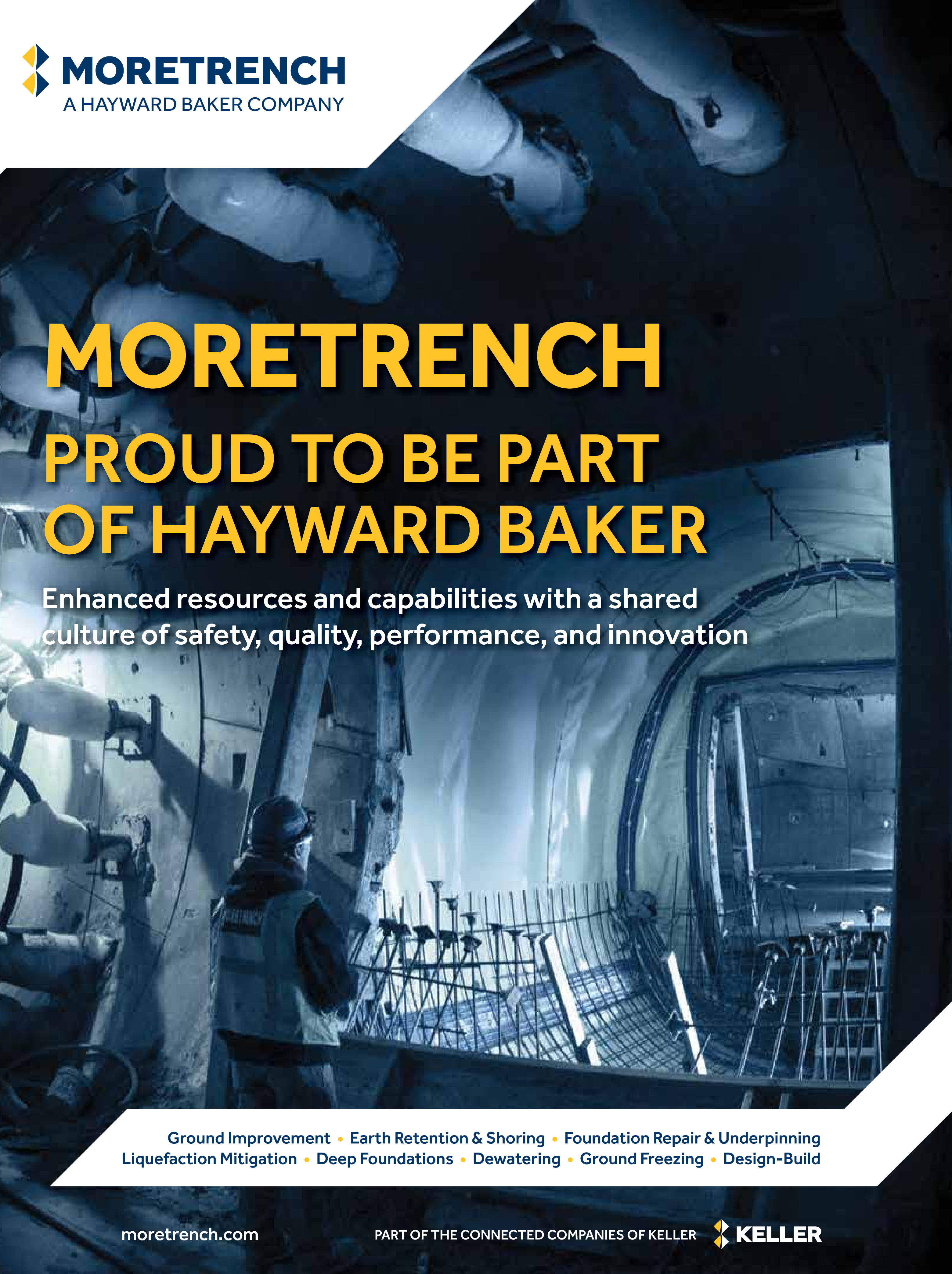
"As the Greater Glasgow area continues to develop, we are modernizing our waste water infrastructure to support the needs of both existing and future customers."

A consortium — the Costain VINCI Construction Grand Projets Joint Venture — was set up to deliver the scheme.

Neil Grosset, the project director of Costain, said: "Completing this scheme, one of the most challenging of its kind in history, is testament to the passion, skills and team spirit of everyone involved in the project.

"The Shieldhall Tunnel is infrastructure that will have a huge positive impact, reducing the flooding risk and improving the environment for the people of Glasgow and the River Clyde now and in the future."

- At 4.7 m (15.5 ft) in diameter, the tunnel will be big enough to fit a double-decker bus inside.
- More than 500 kt (550,000 st) of earth, stone, clay and other aggregates have been excavated in its creation.
- 90 percent of the excavated material has been or will be recycled.
- The new tunnel will be five times longer than the Clyde Tunnel.
- The tunnel will provide 90,000 m^3 (3.2 million cu ft) of extra storm water storage — the equivalent of 36 Olympic-sized swimming pools.
- The giant tunneling drill advanced through the ground at a speed of about 2 cm/min. ■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Tunnel boring machine achieves a breakthrough on the second tube of the Bossler Tunnel

The site crew working with the tunnel boring machine named Käthchen (Katie) has completed the second tube of the Bossler Tunnel. The breakthrough near Mühlhausen im Tale in Baden-Württemberg is another milestone in the construction of the Stuttgart-Wendlingen-Ulm railway line. The Bossler Tunnel is part of the Stuttgart-Ulm railway project and is expected to go into operation in 2022.

When Käthchen broke through the target wall, the earth pressure balance shield (EPB) had completed around 18,000 m (59,000 ft) of tunneling in the sandstone, limestone and claystone rock. The Herrenknecht tunnel boring machine (TBM) finished the second tube of the Bossler Tunnel in early June. Now

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Käthchen achieved top performances. Two months after the start of the drive in the first tube, she reached the 1,000-m (3,280-ft) mark.

New Zealand approves City Rail Link expansion

Expansion plans for New Zealand's City Rail Link (CRL) in Auckland have been approved by Auckland Council and the government. The *New Zealand Herald* reported that the plans will expand rail capacity to accommodate 54,000 passengers per hour, up from the original estimates of 36,000.

The decision will increase the cost of the City Rail Link project by several hundred million dollars. It is already expected to be a $3.4-billion project.

The decision comes after original projections for the Rail Link were found not to reflect rocketing growth in rail patronage across Auckland.

The new agreement means the tendering process can now consider widening tunnel sizes, lengthening platforms at new rail stations to cater for nine-carriage trains instead of six, a second Karangahape Road station entrance and other station work.

Auckland Mayor Phil Goff said the growth in rail travel is a success story for Auckland.

"The growth in popularity of rail travel in Auckland required council to take the decision to increase our investment in the CRL and expand new rail stations to cater for the huge number of people who will be commuting by rail in the next 10 years," he said.

Transport Minister Phil Twyford said these changes would ensure that when CRL opens in 2024, Aucklanders will get a modern and efficient rail service that benefits the entire transport network for decades.

"A decade of under investment in transport infrastructure has bought Auckland to a near standstill," Twyford said.

The council's governing body voted overwhelmingly to expand work on the CRL.

Costs associated with expanding the scope of work for CRL are confidential while the tender process to procure the work is underway.

Exact costs will be known more precisely early next year once tenders are received but could run to the "low hundreds of millions."

CRL costs are shared equally between government and Auckland Council.

Goff said the extra work was not expected to delay the CRL's target opening date of 2024. ■


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Bossler Tunnel: Construction plans changed

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the shell construction of the tubes in this section is completed. The railway tunnel is of great importance for the new Wendlingen-Ulm line and is expected to go into operation in 2022. Travel time on the Stuttgart-Ulm route will be almost halved. Ten million passengers a year will benefit from the railway project.

The second tube of the Bossler Tunnel runs parallel to the first, which the team from ARGE ATA Tunnel Albaufstieg (Porr Deutschland GmbH, G. Hinteregger & Söhne Baugesellschaft m.b.H., Östu-Stettin Hoch-und Tiefbau GmbH, Swietelsky Baugesellschaft mbH) had already completed in November 2016. The Käthchen was then disassembled into its individual parts, transported back to the starting point and prepared for the launch of the second drive. From April 2017, the machine again worked its way continuously through the rock.

Construction of the two tubes was carried out differently than originally planned. After the preliminary geological analysis, the construction team had intended to use Käthchen only over a distance of about 2.8 km (1.7 miles). In the course of further exploration, however, the soil conditions turned out to be more favorable than expected. The TBM from Herrenknecht was thus able to excavate nearly 7.8 km (4.8 miles) in the first tube and even 8.8 km (5.5 miles) in the second tube — which is almost the entire tunnel distance. The work progressed extremely quickly.

The breakthrough in Baden-Württemberg is another milestone in the construction of the Stuttgart-Wendlingen-Ulm railway line.

From the beginning, Käthchen achieved top performances. She was able to cover up to 38 m/day (124 ft/day) and after advancing for six months had already excavated 3 km (1.8 miles) — a strong performance on the part of the site crew. A total of 60,000 segments were installed in the Bossler Tunnel. They were manufactured in the purpose-built factory close to the Aichelberg tunnel portal.

The Albvorland Tunnel is also part of the new construction of the Wendlingen-Ulm railway line. The Herrenknecht tunnel boring machines Wanda and Sibylle are in operation there. So far they have excavated almost 4 km (2.5 miles) of tunnel. As part of the Stuttgart 21 project, Herrenknecht tunneling technology is also working on the Filder Tunnel. The multi-mode TBM Suse has already excavated more than 10 km (6 miles) of the tunnel route planned to connect the main station with the airport.■

Metropolitan board approves $10.8 billion funding for California WaterFix

The Metropolitan Water District of Southern California Board of Directors voted to provide the additional financing needed for the full construction of the California WaterFix project to modernize the state's badly outdated and increasingly vulnerable water delivery system.

The board authorized $10.8 billion for the project to build two tunnels under the Sacramento-San Joaquin Delta. The vote makes Metropolitan Water District the primary investor in the project, which has a total estimated cost of $16.7 billion, Metropolitan Water District said in a statement.

Metropolitan's board took a similar vote in April. However, following that action, two organizations sent a notice alleging violations of the Brown Act in connection with that meeting. Metropolitan responded to the notice disagreeing with its legal conclusion and provided documents in response to a related California Public Records Act request. But to ensure there is no question concerning the validity of the board's consideration of, and its vote on, whether to authorize increased funding of California WaterFix, the board voted on the matter again July 10.

Metropolitan board Chairman Randy Record said the action was taken in an abundance of caution to ensure full public transparency. "California's water delivery system is broken. After years of study, planning and environmental review, we finally have the solution. I am thrilled this project continues to move forward," he said.

The vote more than doubles Metropolitan's initially planned investment in WaterFix. In October 2017, Metropolitan's board initially voted to participate in WaterFix and contribute up to 26 percent of its $17 billion cost, or about $4.3 billion. But the majority of federal agricultural contractors who also import supplies via the Delta have yet to commit to investing in the

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WaterFix: Some funding still needed for project

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project, leaving part of the project's costs unfunded. Metropolitan's board chose to help finance the full 254 m^3/sec (9,000 cu ft/sec) project, with the plan of recouping a portion of that investment from agricultural interests and possibly others once the project is completed.

About 30 percent of the water that flows out of taps in Southern California comes from Northern California via the Sacramento-San Joaquin Delta. But the Delta's delivery system is outdated, its ecosystem is in decline, and its 1,770-km (1,100-mile) levee system is increasingly vulnerable to earthquakes, flooding, saltwater intrusion, sea level rise and environmental degradation.

"The added challenge of dealing with climate change underscores the need to have more operational flexibility in the Delta," Record said.

Attempts to help the Delta have led to regulatory restrictions that have reduced water exports from the region while the ecosystem continues to decline. California WaterFix will modernize the state's water delivery system by building three new water intakes in the northern Delta and two tunnels that will provide high quality water and reduce impacts to fish. It also will contribute to the restoration and protection of up to 6,300 ha (15,600 acres) of critical Delta habitat as mitigation for ongoing construction and operational impacts.

Investing in WaterFix is consistent with Metropolitan's strong commitment to local supply development and conservation. Imported water from the State Water Project helps replenish local ground water basins, meet water quality standards and facilitate water recycling projects.

On June 9, Metropolitan launched a new Landscape Transformation Program through which residents and businesses can get cash rebates for replacing their grass with more water-efficient plants. Metropolitan also kicked off a multi-million dollar advertising and outreach campaign urging Southern Californians to conserve water 365 days a year. ■

Design for Taiwan Strait Tunnel nearly complete

The final design of what would be the world's longest undersea railway tunnel, a 135-km (84-mile) tunnel connecting China and Taiwan, is nearly complete.

The *UK Daily Mail* reported that the design of the proposed Taiwan Strait Tunnel is nearly done, and the project aims to take high-speed trains through the Taiwan Strait at up to 250 km/h (155 mph) by 2030, according to *South China Morning Post*.

However, despite the latest technological progress, political tensions between Taiwan and Beijing — which regards the self-ruled island as a part of its territory — mean construction is unlikely to start any time soon, the report said.

The idea of building a tunnel under the Taiwan Strait has been around since 1996, when it was first proposed by Tsinghua University professor Wu Zhiming following a visit to the Channel Tunnel, which is 37.9 km (23.5 miles) long.

The ambitious project achieved new prominence in 2016, when Beijing included a cross-strait, high-speed rail network in its then-new five-year plan.

According to the plan, the train will travel from Fuzhou province's Pingtan county and arrive in Hsinchu city, southwest of Taipei in 32 minutes. The regions lie on the opposite sides of the Taiwan Strait.

The tunnel's design, completed last year with funding from the Chinese Academy of Engineering, has the growing support of both China's research community and tunneling industry, several senior civil engineering experts told *South China Morning Post*.

Some researchers reportedly said it was possible that Beijing would start to work on the project in a unilateral and largely symbolic move.

The railway's layout consists of a complex of three individual tunnels. Two main passages would be used by trains running in opposite directions. In between them would be a smaller service tunnel that would contain power lines, communication cables and emergency exits, according to the report.

The breadth of its main tunnels would be nearly a third larger than those of the Channel Tunnel, allowing trains to travel faster and carry bulkier cargos. ■

2018 ITA Tunnelling Award finalists announced

The finalists for the 2018 International Tunnelling and Underground Space Association's ITA Awards have been released.

The awards will be presented on Nov. 7 Chuzhou-Nanjing during the 20th Chinese Tunnel and Underground Works Conference (CTUC) from Nov. 5-6, followed by technical visits on Nov.8 in Nanjing, Chuzhou and Shanghai.

After editions in Switzerland, Singapore and Paris, the fourth ITA Tunneling Awards will return to Asia for the 2018 event. The three previous editions of the ITA Tunneling Awards received more than 240 entries and 110 nominations, rewarded 30 projects and personalities and gathered more than 750 attendees.

Major projects of the year

- The West Qinling Tunnel on Lanzhou-Chongqing Railway (China).
- Liantang / Heung Yuen Wai Boundary Control Point Site Formation and Infrastructure Works (Hong Kong, China).
- The Immersed Tunnel of Hong Kong-Zhuhai-Macao Bridge Link (China).
- China's Mega Water Project: Jilin Yinsong Water Supply (China).

Project of the year

- The Queershan Tunnel on National Road 317 (China).
- Gongbei tunnel of the Hong Kong-Zhuhai-Macau bridge (China).
- Foshan Dongping Tunnel (China).
- Vamma 12 Hydropower Project(Norway).

Project of the year including renovation:

- Zarbalizadeh Shallow Tunnel Construction underneath the Operating Railways (Iran).
- Kaikoura Earthquake Recovery Main North Line Tunnels (New Zealand).
- Trenchless tunnel construction of Bukit Panjang MRT entrance and underpass (Singapore).
- Maroggia Railway Tunnel (Switzerland).

A full list of nominees can be found at https://awards.ita-aites.org/. ■

FEATURE ARTICLE

Record attendance at 2018 NAT Conference

by William Gleason, Senior Editor

When work on the latest expansion to Washington, D.C.'s Dulles Airport is completed in 2020, residents of the nation's capital will see a vastly different landscape than they are accustomed to. Not only will the Washington Metropolitan Area Transit Authority (WMATA), locally known as the Metro, decrease traffic with regular service to Dulles Airport, but the area will see the completion of new transit stations, and perhaps more importantly, an end to five decades of construction on the project. The Metro is one of many tunneling projects underway in the United States, and one of many discussed when some of the world's top experts in subway and other tunnel and underground construction came together for the 2018 North American Tunneling Conference at the Wardman Park Hotel in Washington, D.C. June 24-27 to talk about all things tunnel related. A record 1,115 people attended the three-day conference that featured 145 exhibitors in 175 booths and 20 technical sessions that covered all aspects of tunneling and underground construction.

There were 145 exhibitors and a record 1,115 attendees at the North American Tunneling Conference.

The conference kicked off with a keynote presentation from Christine Merdon, deputy architect and chief operating officer of the Architect of the Capitol. Merdon spoke on the topic of managing a mega project, something that resonated with many in the room. Merdon oversees the overall direction, operation and management of the Architect of the Capitol (AOC). In 2016, Merdon and

her team of employees completed extensive renovations on the U.S. Capitol. It was a three-year, $60-million dollar project that repaired more than 1,300 cracks and deficiencies in the 150-year-old cast iron dome, which is the largest dome in the world. The project also included a new coat of paint on the interior of the building for just the fifth time ever. Like tunnel projects that pass beneath high-rise buildings, or buildings of historical and cultural significance, the Capitol renovations had extra pressure to do things right without creating any damage to neighboring areas.

Merdon laid out her management philosophy, explaining the importance of keeping employees and the public informed of the project updates. She pointed out how the project engaged in social media campaigns to control the message and how they used the platforms to celebrate milestones, which helped employees and the public feel more connected to the project.

There were 20 technical sessions and two short courses at NAT.

Merdon noted that, "if you don't tell your own story, someone else will, and it's not always the story you want told."

Although not always as visible as repairing one of the most significant buildings in the world, tunnel projects around the world often face similar scrutiny as did the Capital Restoration project. The work often requires

UCA of SME Chair Mike Roach speaks at the corporate/sustaining members reception during the 2018 NAT Conference.

some sort of disruption to street traffic or stoppages of existing service and is often done beneath densely populated areas.

One such project is New York's Second Ave. Subway project, a $4.5-billion project. The new subway line on the east side of Manhattan opened Jan. 1, 2017 on time while maintaining the budget for the project. Michael Trabold, of AECOM, spoke about how the project team utilized different strategies during the project and how the success was only achieved through all of the parties working together.

From the opposite side of the United States, Jason Choi of WSP USA spoke about the challenges of not just passing below the city of Los Angeles but constructing new transit tunnels beneath the existing tunnels.

It was one of many presentations from the west coast of the United States, which has experienced an impressive amount of tunneling projects in recent years. From the SR-99 project in Seattle, WA to the proposed California WaterFix project, many of these projects were discussed by experts. One such project is the Crenshaw/LAX Light Rail Transit Corridor Project, a three-year project to add cross passages to the corridor.

From Chicago, IL, Miquel Sanchez spoke about Chicago's Tunnel and Reservoir Plan (TARP), a nearly $4-billion program that has lasted more than 30 years and has created, possibly, the largest and longest combined sewer tunnel and reservoir system in the world. The now-completed 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 m x 9 m (14.5 ft 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.

There were also presentations from projects outside of North America including a paper by Fabio Pellegrini, Brendan Daly, Andreea Enescu and Nicolas Swetchine who wrote about sustainable infrastructure tunneling as it applied to the Gotthard Base Tunnel Project and the sustainable reuse of aggregates mines from the tunnel.

Because underground construction generates large volumes of spoil materials and consumes large volumes of natural resources, many infrastructure projects are negatively perceived by the public. To address these perception issues, tunnel owners and developers evaluated the various options for beneficially reusing excavated material to reduce local impacts and advance environmental stewardship through sustainable construction materials solutions. These sustainable construction solutions not only save money and the environment, but also promote a positive community perception for local development.

Another interesting presentation was from Pricilla Nelson of the Colorado School of Mines, who spoke about the need to conduct an appropriate framework and metrics for infrastructure analysis that can include complex systems representations for all sectors — physical, social and environmental. Nelson was also recognized by the UCA of SME as the Outstanding Educator during the awards dinner and banquet. Harvey Parker received the Lifetime Achievement Award and the Outstanding Individual Award was given to David Klug.

The UCA of SME also recognized the Northern Boulevard Crossing as the Project of the Year during the awards dinner.

A pair of short courses, Design and Manufacturing of Precast Segments and Grouting Used in Underground Construction and Tunneling kicked off the week, which concluded with three field trips.

Harvey Parker (L) receives the Lifetime Achievement Award from UCA of SME Chair Mike Roach.

Upcoming events

UCA of SME, along with *Tunneling Journal,* will host the seventh annual Cutting Edge Conference Oct. 29-31 at Loewes Atlanta Hotel, Atlanta, GA. UCA of SME will then return to New York City for the annual George A. Fox Conference on Jan. 23 at CUNY Graduate Center. The UCA of SME will host RETC, June 16-19 in Chicago, IL. ■

FEATURE ARTICLE

Pre-excavation grouting at the Hemphill site — Atlanta WSP Tunnel

Adam L. Bedell, Konner Horton, Don Del Nero and Brian Jones

Adam L. Bedell, Konner Horton and **Don Del Nero**, members UCA of SME, are senior associate tunneling and trenches, geological engineer in training and manager of tunnel construction, TnT Practice, respectively, with Stantec Consulting and **Brian Jones** is civil engineer manager, City of Atlanta, Department of Watershed Management, email adam.bedell@stantec.com.

The City of Atlanta's Water Supply Program Tunnel project includes a 7,315-m (24,000-ft) long, 4-m (13-ft) diameter, hard rock tunnel. A complex aspect of the project involves connecting five, blind bore shafts to the tunnel in a location close to current drinking water reservoirs. During the supplemental geotechnical investigation following the initial contract award, results from additional borehole geophysics were reviewed. Unfavorably oriented fracture sets forced a change in the original pre-excavation grouting program designed for that site. Real-time grout monitoring and geophysical data were compared to provide assurance that the program, as designed, correlated with the in situ ground conditions. Following grouting, results were modeled, and all grouting data were reviewed to determine if grouting was complete.

Project background

The current water supply system operated by the city of Atlanta's Department of Watershed Management (DWM) consists of four, aged, raw-water pipelines, one of which dates back to 1893. Based on previous assessments completed by the DWM, the entire water supply system is at, or will soon reach, its recommended useful life. As such, the city acquired the Bellwood Quarry in 2006 with the intention to create a water storage facility with a volume of approximately 9.1 billion L (2.4 billion gal) to serve approximately 1.2 million people.

The project location is shown in Fig. 1, which is generally in the northwest part of downtown Atlanta, GA. The overall project has been divided into two phases. The Phase 1 project connects the quarry and the Hemphill Water Treatment Plant (HWTP), and the Phase 1 Extension project connects the HWTP to the Chattahoochee Water Treatment Plant (CWTP) and the Chattahoochee River. A 7,315-m (24,000-ft) tunnel with a finished diameter of 3 m (10 ft) connects all three elements. The HWTP location is also where the city's two most proximate drinking water reservoirs are located.

FIG.1

General project location map showing the location of the HWTP in relation to the rest of the project.

Procurement method. The construction-manager-at-risk (CMAR) model was used as the overall project contracting method. Specific to this procurement method involves producing a pricing set of design drawings, specifications, and data and baseline reports, which represent a partial design (typically 60 to 70 percent is used), to allow the CMAR to start pricing the work as design progresses toward final design. As the design evolves and changes are made, assumptions in bid pricing from various subs to the CMAR are reflected in various bid stages.

As changes to the evolving design are made and submitted to the CMAR and owner, specific details are delineated and given to all parties describing changes in the design. This allows for various subcontractors bidding on certain, niche parcels of work (as released by the CMAR) to either adjust their prices based on the revised design or keep their submitted prices based on their perceived risks, design detail revisions, and overall effect of design package revisions.

Hemphill site. The Hemphill site is the point on the project where the conveyance and storage parts of the project needs meet. During the initial phase of the subsurface investigation, a pump station shaft was intended to provide transmission of raw water to and from the tunnel to the HWTP as well as a construction shaft to provide access during construction. During this period, it was communicated from the city that any disturbance from the excavation processes to the existing unlined reservoir was an unacceptable consequence. A pre-excavation grouting program was designed as a risk mitigation tool to reduce the potential for any communication between the reservoir during either of the excavation shafts.

Schedule and blasting restrictions steered the design away from traditional shaft sinking techniques toward using blind boring methods. Blind bores allowed shaft excavation at the Hemphill site to be decoupled from tunnel excavation, subsequently removing it from the critical path of the project. A result of this change in connecting the surface components and the tunnel was that the location of the pumps now needed to be a lot closer to the tunnel. The size and breadth of the pre-excavation grouting program was reduced in accordance with the change in shaft size selection, construction methodology and arrangement.

Geologic conditions. The Atlanta Water Supply Program is located within the Piedmont physiographic province. Many underground components for the project are within a single geologic unit, the Clairmont Mélange. Characteristic of the mélange are interbedded biotite-quartz-feldspar schists and gneisses, with minor granitic lenses. Foliation is very well developed and highly contorted wrapping around the granitic lenses while often displaying a sheared texture. Strike and dip of foliation commonly varies by 35° and the mélange is locally described to as "consistently inconsistent."

During the initial subsurface investigation, boring RWB-15 was drilled based on accessibility while along the tunnel alignment at the Hemphill site. Two other borings, RWB-25 and RWB-26, were drilled based on the original proposed pump shaft and construction shaft locations. Boring RWB-15 showed extremely poor rockmass conditions, as the hole was reamed six times due to stability issues. Packer testing was not performed nor were down hole borehole geophysics due to concerns of lost tooling. While the other borings, RWB-25 and RWB-26, showed some signs of similar geologic conditions (increased weathering along fracture planes, decreased RQD within discrete intervals, and increased permeability values), nothing observed nor tested was as pervasive or severe as RWB-15, which was proximate to the tunnel, while the others were more distal.

As the design evolved from traditionally excavated shafts (drilling and blasting) to blind bores, it was determined that the rockmass close to RWB-15 (as suggested poor ground conditions) warranted additional borings. Additional drilling occurred proximate to RWB-15 and along the tunnel alignment close to the blind bore shaft locations. Borehole stability proved to not be an issue with the additional borings and

FIG.2

Original grout hole layout for blind bore shafts

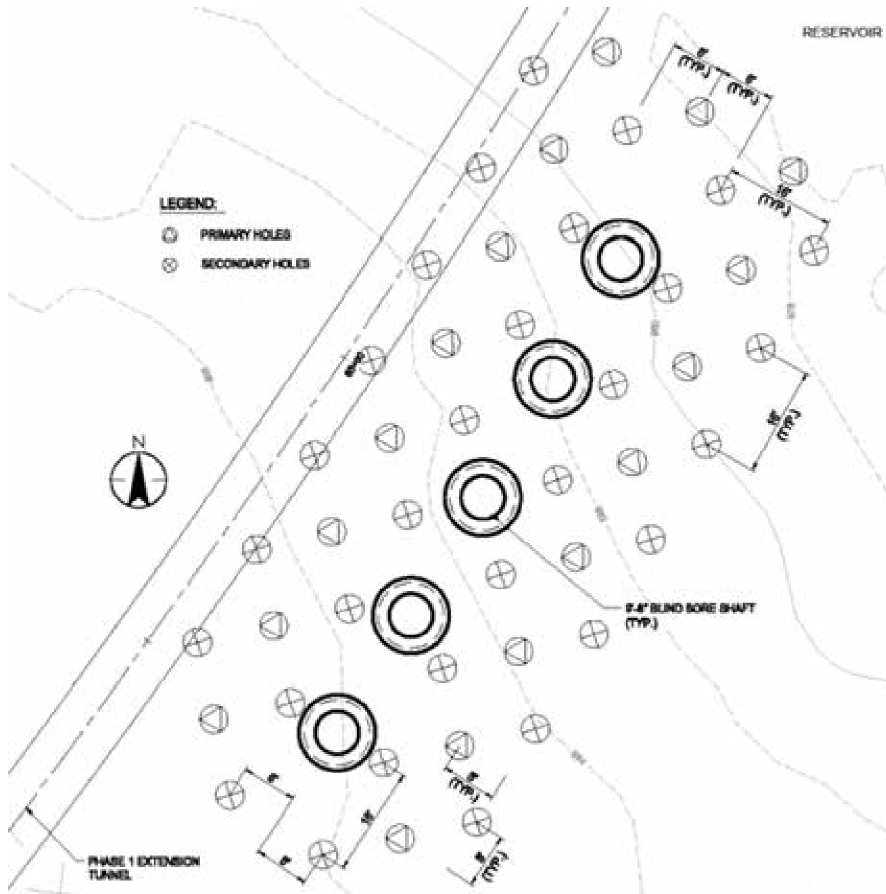
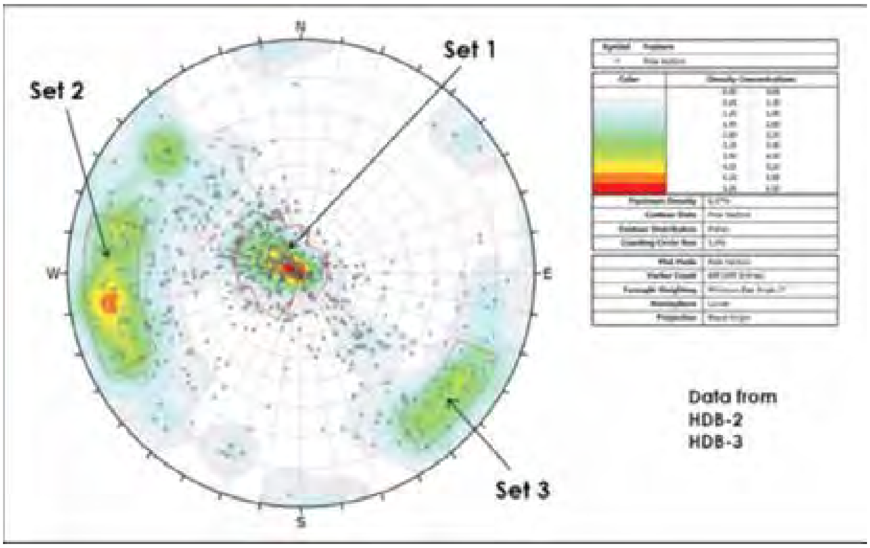


FIG.3



Revised stereoplot from additional analysis from HDB-2 and HDB-3. This was produced after the pricing set of drawings had been issued for bid. Joint sets 2 and 3 were the newly identified joint sets.

packer testing and downhole geophysics were performed. Rock cores collected exhibited characteristics of the lineament hit by RWB-15, but fracturing was less penetrative while packer testing results indicated similar to slightly less permeabilities as shown in RWB-25 and RWB-26.

Design and grouting considerations

There were two underlying premises behind the pre-excavation grouting program. The first was the decree from the owner that under no circumstances shall the existing city water reservoirs be affected by blind drilling processes. Since the #2 reservoir was constructed prior to the 1930s and less than 30 m (100 ft) away from the shafts, it was unlined and, while all information from the subsurface investigation suggested that there was not a connection to the local water table, a risk mitigation measure was required. Second, as common with blind bore shaft sinking techniques, the area around the shaft is traditionally grouted to lower the potential for catastrophic fluid loss. During excavation, the shaft is filled with water to maintain hydrostatic balance and provide for a stable excavation as ground support is not installed. As the large diameter reaming process proceeds to the target elevation, water is maintained in the drilled shaft to keep the excavation open.

During supplemental drilling, the pricing set of documents needed for soliciting bids for the work by the CMAR were then issued and the tunnel contractor, Atkinson-Technique JV, solicited bids for the pre-excavation grouting work package. The initial pre-excavation grouting layout for the blind bore shafts were used. Geophysical results from RWB-25 and RWB-26 suggested moderately open foliation joints (common within this unit) and that inclined grout holes oriented toward the tunnel boring machine (TBM) tunnel would be sufficient to intersect open, variable (relatively flat lying) foliation joints.

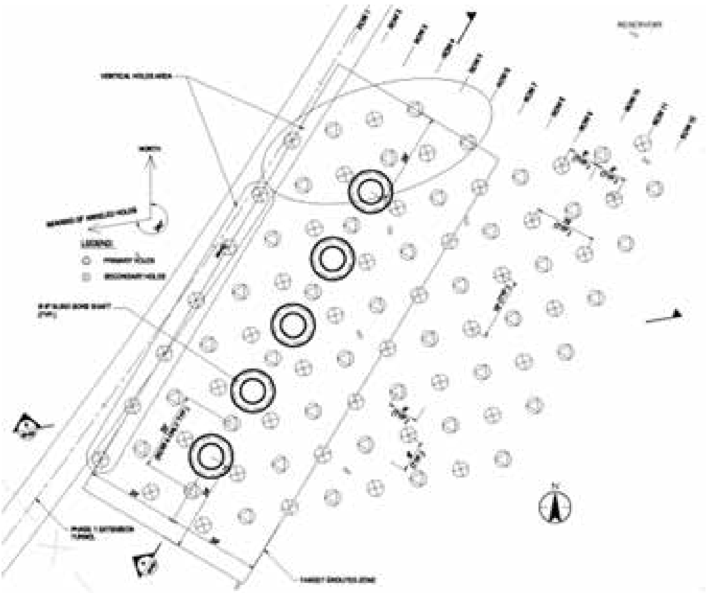
Once the data analysis was complete, it was determined that a change to pre-excavation grouting program was needed. Geophysical information from supplemental borings HDB-2 and HDB-3 indicated two open, high-angle joint sets with apertures ranging from two to four inches, in conjunction with open foliation joints along the "inconsistent" foliation. As designed, the existing pre-excavation grouting program had a high likelihood of missing the newly identified joint sets.

Grout holes were to be drilled at a bearing of 260° at 10° from vertical. This orientation provided the highest probability of hitting both newly identified high-angle joint sets (Set 2 and Set 3) while also targeting the known foliation joint set, as shown in Fig. 3.

Primary grout holes were spaced at 5-m (16-ft) centers with secondary holes split spaced in between them. This pattern results in 2.4-m (8-ft) spacing between primary and secondary grout holes. Grouting started with primary grout holes and, once complete, drilling and grouting of secondary grout holes occurred. Each row had targeted grout elevations from which stages below would be grouted under pressure. This creates a block of treated ground that surrounded the future blind bore drilled shafts. One row near the tunnel alignment contained vertical holes and was drilled and grouted last to help seal off the grouted block, as shown in Figs 4 and 5.

FIG.4

Grout hole layout of the redesigned pre-excavation grouting program.

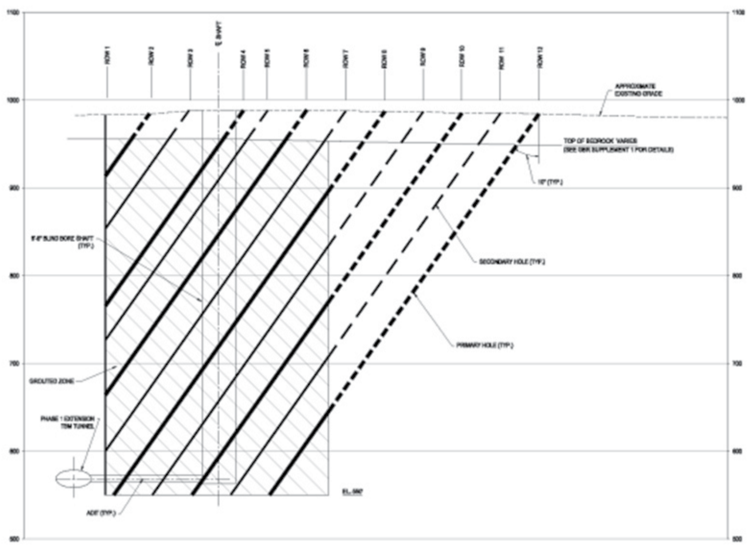


Grout details. Pre-excavation grouting work was paid for as unit rates per bid quantity estimates. Estimated drill footages for both overburden and rock, estimated grout pump times, cement bag estimates and grout stages were provided. Grout mixes provided were by volume starting at 2:1 and progressing to a maximum 0.5:1 water to cement ratio. Refusal criteria was 0.25 gpm or less for five minutes at the full grouting pressures, which were 0.8 psi per foot from the point of injection. For the program, Type III cement was required. Bentonite was not used in any of the grout mixes.

The steps for thickening the grout mix were straightforward per grouting industry standards. Pressure and flow rate were tracked to determine if a mix change was warranted. If pressure increased while flow rate decreased, then the grout mix stayed the same, as the grouting system was functioning properly. When the pressure reached the target injection pressure and the flow rate was below the refusal injection rate, refusal on the stage was called and the packer assembly was moved. If flow rate was constant and pressure did not increase, the grout mix would be stepped

FIG.5

Cross-section of redesigned grout hole layout. Dashed lines represent portions of the grout holes that would not be grouted under pressure.



down and thickened and injection continued at the specified grout mix until changes in pressure or flow rate were observed. Typically, mix changes were made after 380-757 L (100-200 gal) of grout were injected or if it was immediately apparent that the interval was open and a thicker grout would be needed.

Construction

Hayward Baker mobilized to the Hemphill site in April 2016 with drilling scheduled to commence in May. Overburden casing was advanced 1.5 m (5 ft) into rock to ensure the pvc casing was properly socketed into competent rock. Hayward Baker proceeded to install all surface casing for primary grout holes. Grouting was staggered between primary rows as to lower the potential for compromising grout holes that had not yet been grouted through communication from an active grout hole. Production drilling began in July 2016. Grouting of primary grout hole rows started in July 2016 and ended in August 2016. Drilling production secondary grout holes started in August 2016 and grouting all secondary holes and Row 1 (which was designated to be the last row drilled and grouted) concluded in October 2016. In total, 84 grout holes were drilled between primary and secondary portions of the program.

Hayward Baker utilized its proprietary grout monitoring equipment during all grouting. Cement was stored in bulk and then batched and mixed onsite. Grout was delivered to grout carts, small highly mobile tracked equipment that allowed for quick grout injection at various specified grout stages.

The main challenge associated with the program was associated with the ground. It was known that the ground was highly fractured around RWB-15, but conditions around HDB-2 and HDB-3 were better, and they were off the main lineament. With packers traveling along the hole, small pieces of rock would bridge the grout hole. This would prevent the packer from any further traverse towards the targeted depth. This was overcome through either re-drilling the hole and removing the obstruction or by grouting the interval and then re-drilling the interval.

Grout hole drilling was the critical path item of the project. Drilling hours were extended to allow for second shift drilling to reduce the potential for grouting downtime, i.e. the grout carts have nowhere to go. During production grouting, this only occurred once.

Is grouting complete?

Toward the completion of secondary grouting, the natural question asked was whether grouting was considered complete. Schedule impacts concerning other subcontractors were at risk, as there were two other sub-contractors who were scheduled to complete work prior to North American Drilling arriving onsite to begin blind bore shaft drilling. At this point, direct evidence of grouting efforts was not available. The decision was based on numerical grouting results and analysis. The following breaks down what grouting factors were analyzed.

Grout takes. The overall grout take for the program was about 200,600 L (53,000 gal). Primary grout holes took approximately 132,500 L (35,000 gal) of grout and the secondary grout holes took about 68,200 L (18,000 gal) of grout.

The secondary holes took about half of the grout that the primaries took. This reduction in grouting quantities follows the trend of what one would want to see — a progressive reduction in grouting quantities as you traditionally progress past primary grout holes through subsequent grouting.

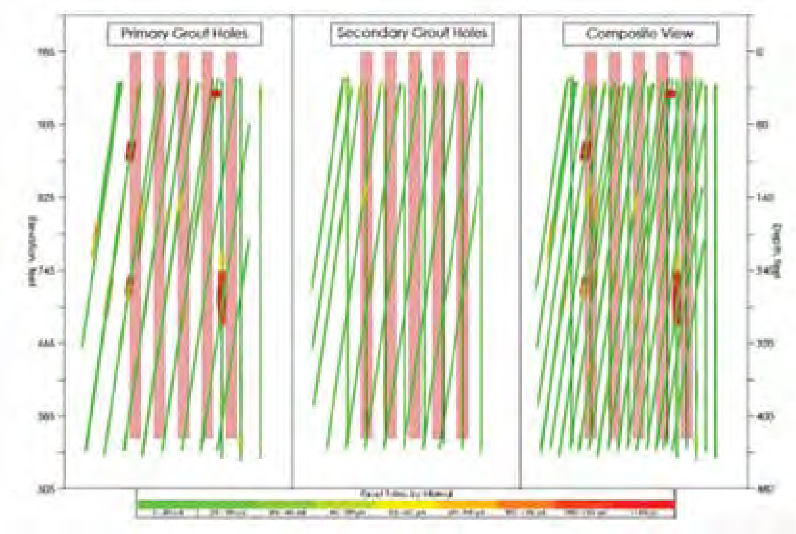
Grout curtain. The grout curtain, as identified by two rows of grout holes around the perimeter of the drilled grout holes, took 68 percent of the total grout injected. This curtain is comprised of both secondary and primary grout holes. This was judged as reasonable, as the holes are on the edge of the area and not within the middle. Grout injected along the edge is not confined and will travel outside the treatment area as far as injection pressure, fracture aperture and cement particle size will allow.

Location of future blind bores. The cross-section of the treated area from around the future blind bores was looked at in relation to grout injected. Grout takes on 3 m (10 ft) of either side of the blind bores along the inclined grout holes, including the area within the blind bore (~9 m or 30 ft total) were assessed. Grouting data from grout stages that fit within this window around the blind bores were analyzed to see grout takes in the immediate vicinity of the bores, not the area overall. Of the total grout injected over the treatment area, the area immediate to the blind bores took only 29 percent of the injected volume. Of the grout injected proximate to the blind bores, 68 percent was 2:1 by volume, 17 percent was 1.5:1 by volume, 8 percent was 1:1 by volume and 7 percent was 0.75:1 by volume. The percentages of mixes used over the entire treated area are within 1-2 percentage points of the values just listed for the 9 m (30 ft) area around the blind bore shafts.

Packer testing data. The packer testing data from HDB-2 and HDB-3 reflect most of the permeabilities in the range of 1 x 10-5 cm/sec to 1 x 10-7 cm/sec, with the remaining zones around 1 x 10-4 cm/sec. Typically, permeabilities lower than 1 x 10-5 cm/sec are considered not groutable. It was judged that the data reflects this as just less than 70 percent of all the grout injected was 2:1 by volume. The thicker mixes pumped reflects the open fractures observed from the borehole geophysical results.

FIG.6

Simplified model depicting grout takes observed for primary grout holes, secondary grout holes, and a composite view.



Typically, when 0.75:1 by volume was injected, refusal occurred quickly, as one would expect.

Grout model. All grouting data were compiled into Civil3D, and modeled, as presented in Fig. 6. The first graphic is only primaries, the second graphic only secondaries and the third graphic is the composite. The blind bore shafts are shaded all the way down. What was observed is that the models corresponded to the grouting data. Following just primaries, large grout takes intersecting with the blind bore shafts was not observed. All the larger grout takes are within the treatment zone, but distal to the blind bore shafts. Following just the secondaries, there are few large to moderate grout takes, but as with the primaries, these are within the treatment zone, but distal to the blind bores. The composite log is judged to demonstrate good overall coverage of the grouting program.

Correlation. In some instances on the grout logs, zones were observed where takes were slightly larger (~54 m or ~180 ft, ~76 m or ~250 ft, and ~103 m or ~340 ft below ground surface). These were interpreted as the foliation joints identified in the field investigation. When looking at individual hole grout takes, there were sometime depths that would correspond between holes, but never really across more than two holes or so. Also, if a zone at 122 m (400 ft) on row four took 5,700 L (1,500 gal), the holes around it (both primary and secondary) were reviewed to see if there were any corresponding elevated values (even if not as large). Similarities in grout take volumes was not readily observed within the area proximate to the blind bores. This condition is also not apparent from the model.

iGrout logs. Lastly, when looking at Hayward Baker's iGrout logs, a large portion of the time is spent achieving refusal. At thinner mixes, this is when pressure filtration takes over and the water is squeezed out of the grout and the finer fractures are filled. All the logs from the area proximate to the blind bore shafts reflect proper refusal without pre-mature thickening of the grout mix or poor injection trends (the trends reflected are what they should be — high initial rate of grout injection with flow rates slowly dropping while pressure remains constant until the refusal criteria is met).

Is grouting complete? The rationale for initiating a tertiary grouting program was not observed. One could inject more grout into the ground (you can always inject more), but the program would be at a point of diminishing returns. Also, based on the overall grout takes, and the grout takes around the blind bores, there was not data available that suggested that there could have been increased take around the blind bores. It was judged that the data set reflects a grouting program implemented as designed. Grout takes decreased between primary and secondaries, there were a few large takes (all outside the blind bore area), but overall the takes were not large, and the amount of thinner mix used reflects the permeabilities of the rockmass from the borings. The data suggest good encapsulation around the treatment area with grout penetration and many of the grout holes communicated to one another. It was judged that impacts to the blind bore construction schedule and the additional cost for a tertiary grouting program are greater than a small benefit from additional grouting that may be gained.

Field verification

Hayward Baker demobilized offsite in October 2016. North American Drilling began reaming blind bore shafts number 1 and number 4 in February 2017. Large diameter reaming to the final diameter began in May 2017 and was completed in July 2017. During the large diameter reaming process, drill cuttings are recirculated to the ground surface. Once on the surface, cuttings are transported to sedimentation ponds via the drill return water where the large and small particulates settle out of suspension and water is then pulled from the ponds for further use.

During the large diameter reaming process, drill cuttings were inspected. Numerous, irregular shaped pieces of grout were picked from the drill cuttings pile. In addition, fluid levels in the shafts and at the reservoir were monitored during drilling. Both the reservoir water level and the water level in the blind bore shafts were constant during shaft reaming. The presence of grout pieces in the blind bore drill cuttings and stable water levels in both shafts and the reservoir further demonstrated that grout penetration was sufficient during the injection process.

Conclusion

An evolving design, coupled with interpretation of supplemental geotechnical information, required a change in the design pre-excavation grouting program as originally submitted to the CMAR for bidding purposes. Grouting results were quantitatively analyzed as well as modeled. Grout logs indicated proper grout injection and grout-rockmass interaction. Prior to blind boring operations, the grouting program was considered complete. During shaft reaming, grout chips and pieces were recovered from the drill cuttings pile and observed stable water levels in both the shafts and the reservoir substantiated grout penetration into the rockmass and provided assurance that the grouting program was implemented as designed.

Currently, the tunnel has been excavated by the five blind bore shafts and four of the five blind bores have been excavated. During mining, some of the grout holes were observed in the crown of the tunnel, but grout was not observed along fractures. Following four to six weeks after excavation, calcium was observed along fractures within the tunnel. Calcium leaching from the grout injected from the surface has been observed in the tunnel by the location of the blind bore adits, providing further substantiation to the effectiveness of the program. ■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FEATURE ARTICLE

The risks associated with TBM procurement and the next steps toward industry change

FIG.1

Modern TBMs like this one used at the TEP II in Mexico City are capable of successfully excavating in soft ground and hard rock.

The majority of tunnels for civil engineering applications are now being constructed using some form of mechanical excavation. Beginning in the 1960s with rock tunnel boring machines (TBM), the tunneling industry has introduced both earth pressure balance (EPB) and slurry pressure balance (SPB) soil machines; mixed soil and rock machines and a variety of different mechanical devices for the construction of small diameter tunnels. Over time, these machines have become more powerful and more adaptable to a wider variety of ground conditions; so much so that tunnels are now being constructed in ground conditions and in the vicinity of third-party impacts that would have been considered beyond the state of the art just 10 years ago. Figure 1 is an example of a mixed ground crossover TBM used successfully at Mexico City's Túnel Emisor Poniente II.

All of the above is highly advantageous for the tunneling industry, but it has also placed a much higher level of risk on the performance characteristics of the tunneling machines, on the contractors operating those TBMs and on the manufacturers of those machines. Most of the risks for a tunneling project are associated with creating the space inside of which the finished facility will be constructed. In order to create that space, the tunnel contractor must make many decisions about the best way to excavate the ground, the best way to control the ground at the face of excavation and the preferred method for supporting the ground around the tunnel in a manner that is safe for the workers and stable with respect to all of the overlying and adjacent existing structures. If it is proposed to use some form of TBM in order to build the tunnel, then the TBM becomes central to all three of these activities and becomes an integral part of managing the risks associated with these activities.

The primary objective of this article is to discuss how the TBM manufacturer can, and should, work together with a tunneling contractor in order to minimize and manage (i.e. control) many of the risks associated with a tunneling project. In general, and as all members of the tunneling fraternity are well aware, there are lots of risks associated with every tunneling project that need to be identified, allocated and managed as a result of the various contracts between the project owner and the designer, between the

Lok Home and Gary Brierley

Lok Home and Gary Brierley, members UCA of SME, are president the Robbins Company and president, Dr. Mole, Inc., respectively, email HomeL@robbinstbm.com, gbrierley@drmoleinc.com.

project owner and the prime contractor and between the prime contractor and various subcontractors and equipment suppliers; including the TBM manufacturer. As with any contract, the responsibilities of the various parties need to be clearly stated and the basic framework of the contract should create a fair and equitable working relationship between the parties. This becomes a most interesting challenge for the TBM manufacturer, since he is providing an extremely complicated and expensive piece of equipment that is central to project success; not only as a result of its mechanical performance and durability but also as a result of how it is operated by the contractor. Hence, many things must go right in order for the TBM to contribute in a positive manner to the successful outcome of a tunneling project.

FIG.2

The McNally Roof Support System utilizes steel slats extruded from pockets in a TBM's roof shield.

TBM performance characteristics

The TBM contributes to project success in two important ways:

1. Its mechanical performance and durability.
2. Its ability to help control potentially adverse ground reactions.

For instance, for a rock tunnel, the TBM must be able to dependably excavate the rock and to allow for all aspects of equipment maintenance in a predictable manner. Prior to bid, the TBM manufacturer provides the bidding contractor with operating criteria and expected TBM technical capabilities based upon geological information provided by the owner's consultants and the project's TBM specification. This is then incorporated by the contractor into his bid. In general, rock tunnels do not have negative impacts on adjacent existing structures and, in most situations, it is relatively easy to install adequate support in the tunnel utilizing equipment provided as part of the TBM unless the tunnel is in highly faulted ground, stressed ground or mixed-face conditions. Figure 2 shows an example of an easy-to-install ground support system for open-type TBMs known as the McNally roof support system.

However, operating criteria for EPBs, SPBs and mixed soil and rock TBMs are far more complicated than rock TBMs because of the enormous variations in different types of soil. Soil behaviors can vary from firm ground needing little face control and/or support to flowing ground and high water pressure, which can create problems both for the machine itself and for adjacent structures. In addition, soil TBMs have a more difficult interface between the machine's inherent performance characteristics and how that machine is operated by the contractor, particularly in highly variable subsurface deposits. Hence, a perfectly good TBM can be operated in a manner that causes problems for the equipment, problems for tunnel production and problems for third parties.

The bottom line is the preparation of a listing of required TBM capabilities. These capabilities should be mutually agreed upon both by the tunnel contractor and by the TBM supplier, and must also meet the consultant's criteria. The specifications must be completed prior to commencement of TBM manufacturing. Listed below is a general example of TBM requirements.

- Proper size with sufficient drive power.
- Cutterhead design and excavating tools.
- TBM shield and working chamber.
- Ground conditioning at the face for either rock or soil or both.
- Thrust capacity and steering control.
- Spoil removal within the TBM and along the tunnel.

- Spoil weight/volume verification.
- Bearing seals and tail seals.
- Shield gap and annulus injection system.
- Facilities for ground support installation.
- Guidance system and alignment control.
- Data loggers and TBM performance monitoring.

All of the TBM technical capabilities are incorporated into a technical proposal prepared by the TBM supplier with extensive input from the tunnel contractor. In essence, this single document represents one of the most important parts of the planning effort for a successful tunneling project built with a TBM. When the TBM disappears through the shaft wall or portal face, the assumption is that it is equipped with all of the technical capabilities needed to make it to the exit end of the tunnel. If that is not the case, then significant project delays are in the offing, either as a result of reduced rates of advance or because of TBM modifications needed while in the tunnel. A TBM can be modified while underground using a suite of options known as difficult ground solutions (DGS), to be discussed later in the paper. However, these features are much more effective at reducing risk if they are included on the TBM before it is launched.

The TBM contract document

In order to accomplish the performance capabilities listed above, the TBM supplier must design and manufacture a TBM for each specific application. With respect to the TBM's mechanical performance and durability, the TBM is expected to operate effectively under harsh conditions and for the duration of construction, and it goes without saying that the different parties associated with a project will have radically different concepts about the meaning and the expectations associated with the word effectively. One of the most common causes of claims, disputes and lawsuits is the occurrence of "unfulfilled expectations" by one or more of the parties in a contractual relationship. Hence, and as a result, one of the most important goals of contract preparation is to forthrightly and unambiguously control project expectations in the contract wording. It is also important as a part of contract preparation to establish the fair and equitable distribution of project risks among the contracting parties.

The two most important sources of the risks associated with TBM performance are how well the TBM interacts with anticipated ground conditions with respect to tunneling productivity and with respect to possible negative impacts on overlying and adjacent existing structures. Hence, the contract document for the TBM supplier should have well-developed descriptions for both anticipated ground conditions and for major third-party interactions as provided in the project-specific geotechnical data and baseline reports. In addition to the geotechnical and third-party considerations, there are numerous other items that should be established in the TBM contract document and given below is an annotated listing of some of those items.

Warranty — Clearly, the TBM should be expected to perform reliably and at progress rates provided by the TBM supplier, and a warranty paragraph to that effect should be included.

Limitation of liability — However, a warranty only applies to the TBM itself and not to liquidated or consequential damages, force majeure, duty to defend or project delay. Hence, the TBM supply contract should contain a valid limitation of liability paragraph addressing those topics.

Differing site conditions (DSC) — The TBM contract should also provide access for the TBM supplier to the legitimate application of the DSC clause. If the ground is found to be materially different as indicated by the prime agreement, then the TBM may need to be modified after the drive has begun.

Dispute review board — The TBM supplier should also have access to some form of dispute resolution as part of its contract.

Safety — The TBM supplier is not responsible for on-site safety unless the TBM itself contributes to a problem. Hence, whenever TBM supplier personnel are on-site, they are there as guests under the prime contractor's safety plan as explained in OSHA regulations.

Flowdown requirements — The TBM supplier must be extremely careful about flowdown requirements from the prime agreement that may or may not be applicable to the TBM supply contract. In general, the TBM supplier should not accept a blanket statement that all obligations contained in the prime contract apply to the TBM supplier. Some examples of problematic flowdown requirements are indemnification, duty to defend, liquidated damages, hazardous materials, default and/or termination provisions and waiver of rights.

Standard of care — The TBM supply function also involves a large component of engineering services, and the TBM supplier should only be deemed to be liable for those services if they were performed negligently. This standard of care is also closely related to the TBM suppliers' proposed scope of services as explained later.

Probably the most important part of the TBM supplier's agreement is a detailed description of their scope of services. Almost no matter what is written in the body of the contract, the TBM supplier can control its potential liabilities by explaining in detail the services it intends to provide and, equally important, those services and/or project activities for which it is not responsible. For instance, the TBM, as supplied, will have certain performance capabilities but that does not mean that the TBM will be operated and/or maintained in a proper manner in the field. Improper TBM operation and maintenance can be a significant risk for a tunneling project, and the TBM supplier must limit its liability for inappropriate TBM operation. The TBM manufacturer cannot be held responsible for the damage caused by an unqualified TBM operator or by unqualified modifications to the TBM. Figure 3 shows an example of a modification installed by a contractor that may have contributed to significant equipment downtime).

Managing TBM risks during construction

The risk profile for a tunneling project can be divided into four steps:

1. Risk identification.
2. Risk avoidance and/or minimization.
3. Risk allocation.
4. Risk management.

All activities associated with risk identification, risk avoidance and risk mitigation take place during the planning and design stages of a project, wherein the owner and his design consultants attempt to formulate a risk profile that is described in the risk literature as low as reasonably practical (*SME Guidelines for Risk Management*, 2015). This is an extremely important responsibility on the part of the owner and its designers, as it represents a sincere desire by those parties to provide a contract document for bidding where the risks for all parties to the contract have been minimized as much as possible. At that point, the owner's remaining responsibility is to allocate any remaining risks between itself and the prime contractor in a fair and equitable manner in the contract document for construction. After award, this process continues, as the prime contractor continues to allocate its risks to various subcontractors and equipment suppliers. Hence, the question remains, how much tunneling risk can be fairly and equitably allocated by the prime contractor to the TBM supplier.

For instance, and as previously discussed, the TBM cannot be expected to perform in a ground condition that is known to be materially different as indicated by the contract document. Other examples of dramatic differences between TBM performance characteristics and operational requirements would be as follows:

Gassy ground — The TBM can be equipped with gas monitors, but the prime contractor is still responsible for ventilation issues and evacuation procedures.

Over-excavation — The TBM can be equipped with monitors that show how much spoil is being removed from the tunnel, but that doesn't necessarily stop the TBM operator from over-excavating. Presently, there is no single monitoring system available that can accurately measure the volume and density of material being removed from the tunnel. Therefore, several monitoring systems should be utilized on each project (Robinson et al., 2012).

Guidance — The TBM will be equipped with a laser guidance system, but survey errors may still cause the machine to go off of alignment.

TBM maintenance — Poor TBM maintenance by the prime contractor may cause TBM utilization to suffer or premature failure of components to occur through no fault of the TBM supplier.

Operator training — The TBM supplier can offer training, but the operator qualifications and capabilities are the responsibility of the contractor. Improper operation of equipment is one of the leading causes of tunneling delays.

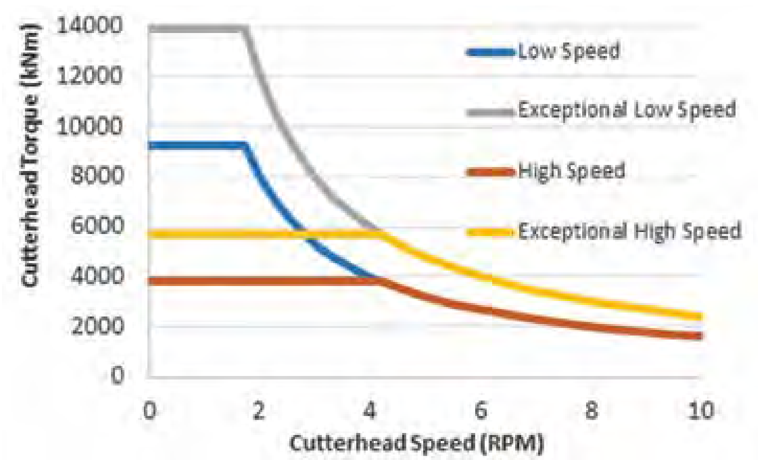
The complete list of TBM performance capabilities versus TBM operational responsibilities is long and can result in unfulfilled expectations for a tunneling

FIG.3

An example of contractor-added machine modifications that were unnecessary.

FIG.4

Example torque-speed curve for a TBM with two-speed gearboxes.



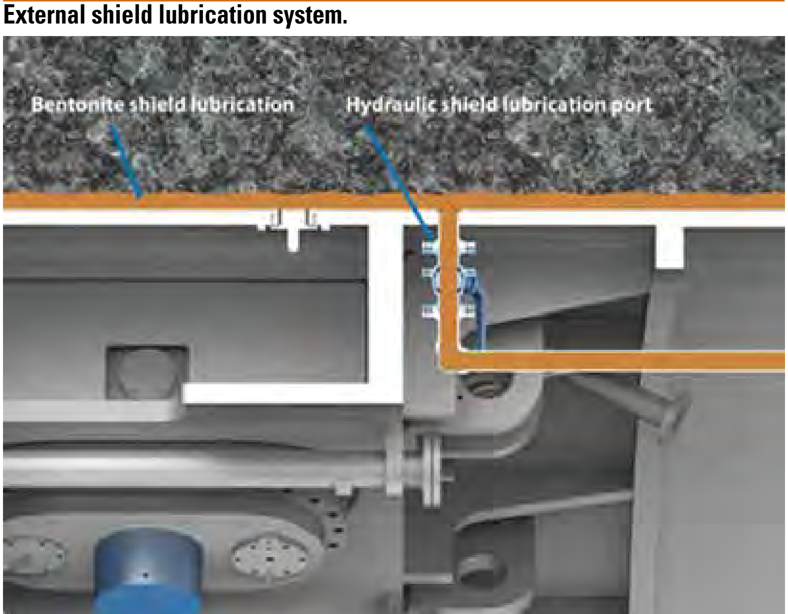
project. The main issue raised by these issues is how can we write a good contract that clearly defines the design of the machine and the TBM supplier's responsibility, as well as the contractor's responsibility and scope of machine operation?

Next steps toward industry change

Looking at TBM procurement differently. There must be a more objective way for owners and contractors to view risk, other than looking for the lowest equipment price and highest willingness to accept risk from a TBM supplier. In fact, a correctly designed TBM is the key to a project's success, and correct machine design, even with increased initial cost, is part of that formula to success.

FIG.5

External shield lubrication system.



Field results have shown, time and again, that a TBM built with risk insurance-type features (such as probe drills, shield lubrication, etc.) can have a huge impact on a project's success in terms of schedule, cost and safety. It is better to build features into the machine from the start as part of a comprehensive risk management strategy, than to add them in the tunnel after an unforeseen event has occurred or the machine has become stuck.

Even when risks are considered low, it is still better to equip the machine from the outset with the tools needed to get through unforeseen conditions. These tools have been tested in the field and can mean the difference between project success and failure. Robbins currently is equipping several shielded, hard rock TBMs with DGS — a suite of options that can prevent a machine from becoming stuck and can enhance visualization of the ground around the TBM (Harding, 2017). For example, two-speed gearboxes allow a rock machine to shift into a high torque, low RPM mode to get through fault zones and collapsing ground without becoming stuck. Figure 4 is an example two-speed gearbox torque-speed curve.

Shield enhancements, such as external shield lubrication, can further keep a machine from becoming stuck. Radial ports in the machine shield can be used to pump bentonite between the machine shield and tunnel walls to reduce friction (Fig. 5).

Emergency thrust systems are another addition that can be deployed when ground convergence occurs. Additional thrust jacks between the normal thrust cylinders can supply added thrust in a short stroke to break loose a stuck shield (Fig. 6).

Remedying contract structures to reduce risk and cost

A contract structure that clearly defines the responsibility of the supplier and the responsibility of the contractor while allocating risk fairly is what is needed. Contractors must take responsibility to allocate the appropriate amount of risk given the limited capabilities of a given machine.

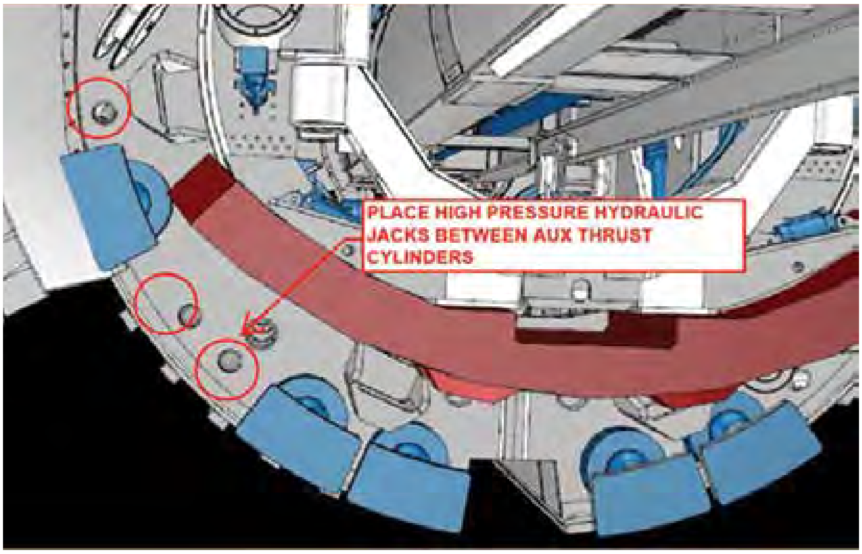
Part of more accurate risk estimation lies in the industry's ability to find and utilize consultants who are up-to-speed on the latest in TBM technology and mixed ground capabilities, and therefore, can accurately specify the technical capabilities required of a given machine.

Another aspect of inexperience and improper risk allocation is the extreme specifications that are being created for many current projects. These specifications vastly overestimate the given risks of a project (e.g., if test results show 200 MPa rock, they will want to have a solution capable of excavating 300 MPa. If tests show 100 L/s water inflows they will want a solution capable of handling 200 L/s). These types of specifications increase the complexity of a TBM needlessly and thereby increase the cost of the end product to the owner.

Risk-based cost and schedule estimation is being used on more projects and will be an important part of the process moving forward (Sander et al., 2017). But even with these tools and the industry guidelines available — such as those produced by the UCA of SME (O'Carroll & Goodfellow, 2017) — an increase in industry knowledge of those tools is needed. If these tools are not used, the unequal allocation of risk will continue.

FIG.6

Possible locations of additional thrust jacks.



Operating the TBM differently

When an adequate Geotechnical Baseline Report (GBR) is lacking and/or when risks can't be properly quantified, a push for continuous probe drilling should be made by all parties involved. Writing continuous probe drilling into the contract can and has effectively reduced risk — but we need more buy-in from the industry. Through continuous probing, crews can generate an in-tunnel GBR concurrent with advance. This GBR could be used to analyze trends and predict upcoming transition zones. The requirement for an in-tunnel GBR would effectively force contractors to take the time to analyze what is ahead of them — a small price to pay when a big feature is detected in time to save the tunneling operation.

In addition, the TBM supplier should have more ways to address improper operation of the TBM by the contractor. The supplier should have access to the Dispute Review Board as readily as the contractor so that justification of a lawsuit, or lack thereof, can be determined by all parties involved.

Summary and conclusion

The tunneling industry has seen enormous advancements in the performance capabilities of all forms of TBMs (soil, rock, mixed rock/soil and small diameter) to the point that tunnel success has become intimately related to those capabilities. As an additional result of those advancements, tunnel designers and tunnel contractors are continuously pushing the envelope for the size, length, depth and alignments of tunnels in difficult ground and in the immediate vicinity of sensitive, existing third party structures. Hence, tunnel designers and contractors are becoming highly reliant on the knowledge and experience of TBM suppliers to rise to the challenge of those increasingly challenging projects. However, there are limits. The TBM supplier's financial opportunity for providing the equipment cannot be allowed to outstrip its responsibilities for project risks. Machine capabilities are still limited and cannot be expected to serve as the primary excuse for unrealized project expectations. In the final analysis, all parties involved with the successful completion of a tunneling project including project owners, designers, prime contractors, subcontractors, suppliers and insurance companies must accept their fair share of risk commensurate with the benefits associated with their contribution to the finished facility. From that perspective, the TBM supplier is not high on the list of project beneficiaries and, therefore, cannot be expected to assume unreasonable project liabilities relative to their role in the project. Hence, unreasonable attempts to transfer project risks to the TBM supplier must be controled in no small measure so as to actually protect the integrity of the tunneling industry. ■

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FEATURE ARTICLE

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

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

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

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

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

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

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

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

by William Gleason, Senior Editor

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

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

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

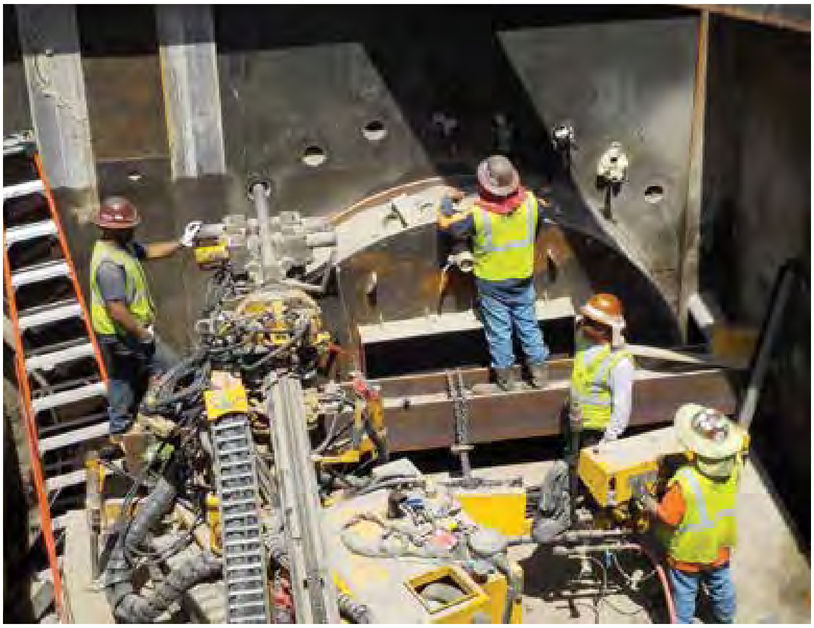
and County of Denver. "We did know that at one time there was a 175 cm (69 in.) reinforced concrete pipe somewhere near RTD's property but not exactly where it was or the condition of the pipe. We had heard that it was potentially crushed, but we later found out that it was not crushed and that it had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

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

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

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

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



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

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

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

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

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

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

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

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

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

Grout canopy

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

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

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

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

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

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

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

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

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

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

The Robbins Company

EXECUTIVE COMMITTEE

Two new directors join the UCA Executive Committee

Alan Campoli and Mark Johnson have been elected to serve on the UCA Executive Committee from June 1, 2018 to June 30, 2022. Mike Mooney and Leon (Lonnie) Jacobs were relected for a second, four-year term.

ALAN A. CAMPOLI is director of Energy & Natural Resources at ECSI in Lexington, KY and senior consulting engineer for Jennmar. He has more than 30 years of engineering and sales experience focused on rock reinforcement, standing support, ground water containment and ventilation issues, for tunneling, mining and construction.


CAMPOLI

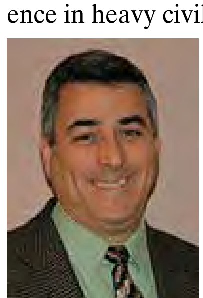
Campoli holds a B.S. degree in mining engineering and an M.S. degree in engineering management both from the University of Pittsburgh. He earned a Ph.D. in mining engineering from Virginia Tech. He is a licensed professional engineer, a certified mine foreman, a registered member of SME and an inventor (patented). He taught mineral economics and mine valuation at the University of Kentucky and is the author of more than 40 technical publications. He is a Distinguished Member of SME and former chair of the SME Pittsburgh and Central Appalachian sections. He has served SME on the Peer Review Editorial Board, the Professional Engineers Exam Committee, the Research Council and Program Committee. He is a member of the American Society of Civil Engineers and the American Society for Testing and Materials International.

MARK JOHNSON has more than 25 years of specialized experience in tunnel and underground engineering. He is currently global director for tunneling and ground engineering for Jacobs Engineering leading a group of nearly 900 tunnel and geotechnical engineers. His experience includes tunnel projects in the United States, the United Kingdom (UK), Canada, Malaysia and Singapore, including a significant number of design-build projects. He recently served as the project director for the design team that delivered the Blue Plains Tunnel in Washington D.C., winner of *ENR* magazine's 2016 "Best of the Best" project award.


JOHNSON

Johnson has served as a member of the organizing committees for RETC and the George A. Fox Conference and is also a member of an SME Strategic Committee, the British Tunneling Society and the Institution of Civil Engineers. He received a BEng. in civil and structural engineering from Sheffield University, UK, in 1992.

LEON (LONNIE) JACOBS has more than 34 years of experience in heavy civil and underground construction in the New York metropolitan area. He earned a B.S. cum laude in civil engineering from Northeastern University, Boston, MA, in 1985, and an M.S. in construction management from Brooklyn Polytechnic University in 1988. He joined Frontier-Kemper in 1995 where his professional responsibilities have covered all facets of heavy construction, from project management to engineering, and include experience in design, scheduling, cash flow, insurance, safety, accounts payable and receivable, payroll, estimating, budget production, risk management, quality control, change-order negotiation, customization of equipment, design of specialized equipment, value engineering, human resources and strategic planning.


JACOBS

Jacobs is a member of the George A. Fox Conference Committee and chair of the North American Tunneling Conference Planning Committee. He is a licensed professional engineer in New York, New Jersey, Maryland and Virginia. He is also a member of Chi Epsilon, The Moles, the New York State Society of Professional Engineers and the American Society of Civil Engineers.

MIKE MOONEY is a professor of civil engineering and holds the Grewcock Distinguished Chair of Underground Construction and Tunneling (UC&T) at the Colorado School of Mines. He leads the interdisciplinary Center for Underground Construction & Tunneling and is also a director of SmartGeo, an innovative interdisciplinary graduate program to advance intelligent geosystems — natural and engineered earth structures that sense their environment and adapt to improve performance.


MOONEY

Mooney is a licensed professional engineer and has more than 24 years of academic and consulting experience in civil engineering and construction. He is a licensed professional engineer. He received a B.S. in civil engineering from Washington University in St. Louis, an M.S. in civil-structural engineering from the University of California-Irvine and a Ph.D. in civil-geotechnical engineering from Northwestern University. His research and

(Continued on page 60)

EXECUTIVE COMMITTEE NOMINATIONS

UCA seeks nominations for the Executive Committee

The UCA Division seeks recommendations and nominations from all UCA members for interested individuals to serve on the UCA Executive Committee for the term 2019 to 2023. Current bylaws call for a 19-person Executive Committee. Membership on the committee consists of three officers, chair, vice chair and past chair, and four directors from each of the following areas: engineers, contractors, owners and suppliers. The UCA Executive Committee seeks a balanced representation from the four areas, but it has the option to have more members in one or more areas and fewer members in others.

If you would like to nominate someone for consideration, forward your recommendation to Genny Homyack (homyack@smenet.org) at SME headquarters by Nov. 30, 2018. The individual nominated must be a member of the UCA of SME. Staff will compile all nominations for the UCA Nominating Committee's consideration.

A few items are requested to help with the committee's decision.

- Identify in which of the four areas the individual should be considered for service: engineer, contractor, owner or supplier.
- Provide a brief biography or résumé outlining the person's industry experience and service to UCA and other professional organizations.

Note for past submissions

If you have submitted candidates for consideration in the past three years, please resubmit or send a note to check on the status of your nominee. Traditionally, all nominees are resubmitted for consideration for three consecutive years if they have not been selected for the executive committee slate. Your diligence will ensure that all qualified candidates are reviewed. ■

UCA SCHOLARSHIPS

UCA awards scholarships at NAT 2018

Every year, the Executive Committee of the UCA of SME awards several scholarships to the most qualified candidates who have applied. In June 2018, three awards were made at the UCA luncheon during the North American Tunneling Conference (NAT) in Washington, D.C. In addition to the cash awards, winners received travel expenses and free registration to the NAT.

Applicants are required to be enrolled in an undergraduate or graduate academic program related to tunneling or underground infrastructure. Hands-on experience in the underground environment is also a plus. The Scholarship Committee of the UCA evaluates all applicants based on categories that include, but are not limited to, the candidates' passion for underground work, their potential for success and academic achievements to date, the strength of the candidates' recommendations from educators or employers, any prior UCA involvement and their financial need as presented in the application.

The UCA Executive Committee and the Scholarship Committee ask all UCA members to promote and disseminate the availability of the scholarship and the application process within their organizations — especially to relatives and friends.

Any prior experience, such as internships or summer jobs in the tunneling or underground industry in the planning, design, construction or oper-

(l-r) Yuanli Wu, Rajat Gangrade and Saleh Behbahani received UCA scholarships at the NAT 2018 luncheon.

ation of tunnels and shafts, is a benefit to the applicant being considered. The application is available online at www.smenet.org/students/grants-scholarships from Sept. 15 to Dec. 8, 2018.

2018 scholarship winners

RAJAT GANGRADE is pursuing a Ph.D. in underground construction and tunneling at the Colorado School of Mines (CSM). He earned an M.S. degree in civil and environmental engineering, with a concentration in geotechnical engineering, from Virginia Tech, where he worked as a research assistant and a teaching assistant. He holds a B.Tech degree in civil and environmental engineering from Veermata Jijabai Technological Institute in India. He has worked as a geotechnical engineer II for AECOM in Mumbai, India and as a geotechnical engineer I for CH2M in Des Moines, IA. Gangrade is an officer in the UCA/SME Student Chapter at CSM. He is also a member of the American Society of Civil Engineers (ASCE) and the Indian Geotechnical Society.

SALEH BEHBAHANI is working toward a Ph.D. in civil engineering at Louisiana Tech University. He received M.S. and B.S. degrees in mining engineering from the Islamic Azad University in Iran. He has worked for Perlite Construction on the Tohid Urban Tunnel and has worked as an intern for the Moshanir Co. in its Department of Rock Mechanics. He is currently serving as coordinator of the Trenchless Technology Center's Utility Investigation School and Subsurface Utility Locating with GPR at Louisiana Tech. Behbahani is a member of ASCE, Southern African Institute of Mining and Metallurgy and the UCA of SME.

YUANLI WU is a Ph.D. candidate student studying geotechnical engineering at the CSM, where her research focus is on soil conditioning in earth pressure balance-tunnel boring machine tunneling. She is president of the UCA of SME student chapter. She received an Edna Bailey Sussman internship and participated in a collaborative research between the USGS-LHP and CSM to investigate the mechanics and hydrologic conditions that trigger shallow landslides. She was also a geotechnical engineering intern for Arup in San Francisco, CA. She holds B.S. and M.S. degrees in geotechnical engineering from China University of Geosciences. ■

DEEP FOUNDATIONS INSTITUTE

DFI announces the new Tunneling and Underground Systems Committee

The Deep Foundations Institute (DFI) announces the formation of the Tunneling and Underground Systems Committee. The committee is focused on identifying and facilitating the advancement of new methods and technologies for design, construction, inspection, maintenance and operation of tunnels and underground systems. Technical focus areas include conventional and mechanized excavation methods, design practices for tunnel liners, the use of new materials in construction, waterproofing and water control systems, contracting methods, and the allocation of risk and construction practices.

The committee plans to foster technology transfer among the owners, stakeholders, designers, contractors and material suppliers involved in the use and construction of tunnels and underground structures; foster collaboration with the academic community, equipment suppliers, and major tunnel contractors and owners to address research needs and knowledge gaps and promote the education and training of graduate and undergraduate students to develop emerging industry leaders in this field of practice.

The new committee is co-chaired by **JAMES MORRISON**, a vice president of COWI, and **DAVID R. KLUG**, president of David R. Klug and Associates.

Morrison has more than 35 years of civil engineering experience in large and complex underground and heavy construction: bridges, dams, hydroelectric generating plants, highways, deep excavations, transportation and water/sewer tunneling projects. He has participated on some of the largest tunneling projects in North America. He has written numerous technical papers and served as a president of the Deep Foundations Institute and the Cleveland Section of ASCE. He is a licensed professional engineer.

Klug provides international and national manufacturer representative services to the underground heavy civil and mine construction industries. He has more than 40 years of industry involvement in many of the major tunnel programs constructed in the United States and Canada. In conjunction with his European clients, he conducts industry outreach seminars to Europe for people from the U.S. and Canadian tunneling industry to study European methods of tunnel construction and contract delivery practices. He is past chair of UCA, a member of the George A. Fox Conference Committee, a member of The Moles and the Associated General Contractors of Western Pennsylvania.

To learn more about the Tunneling and Underground Systems Committee visit www.dfi.org/commhome.asp?tuns. DFI, www.dfi.org, is an international association of contractors, engineers, manufacturers, suppliers, academics and owners in the deep foundations industry. ■

EXECUTIVE COMMITTEE MEETING

Highlights of the UCA Executive Committee meeting

The Underground Association of SME (UCA) held its Executive Committee (EC) meeting June 27, 2018 at the Marriott Wardman Park Hotel, Washington, D.C. Executive Committee members present included Mike Roach, chair; Robert Goodfellow, vice chair; Arthur Silber, past chair; Lonnie Jacobs, Mike Rispin, Mike Mooney, Red Robinson, Matthew Preedy, Len Worden, Michael Smithson, Rich Redmond, Erika Moonin, Jack Brockway, Edward Dowey, Pamela Moran, Paul Schmall and Mike Vitale. Guests attending were Alan Campoli, incoming executive committee member and Demetrico Criscuolo, representing the Young Members program.

SME staff attending were David L. Kanagy, executive director; Melanie Penoyar-Perez, director of operations; Tara Davis, programming manager; Cori Knasinski, meetings manager and Bill Gleason, senior editor, *T&UC.*

Mike Roach called the meeting to order and all present introduced themselves. Arthur Silber gave a safety share. The minutes from the Jan. 24, 2018 meeting were approved.

Summary of ITA activities

Roach presented Randall Essex's report on the most recent ITA/WTC meeting held in Dubai, UAE April 22-25, 2018. Approximately 1,700 attended the event. Professor Edward Cording gave the Alan Muir Wood lecture, and about 50 people from the United States attended. Roach was the voting representative from the United States. He noted that Essex invested a tremendous amount of time in assisting the Dubai organizing committee and was probably responsible for a successful event. All of the ITA working groups held meetings in Dubai. A summary of the U.S. representatives to the working groups was distributed. Anyone who is interested in a working group without official representation from the United States should contact Essex. See article on page 60.

Roach discussed a recent meeting that was held with representatives from several Latin American countries, Mexico and Canada to form an Americas ITA Forum. The forum would be hosted at each WTC event and would allow an exchange of information on the ITA issues affecting the Americas. Preparations are now underway for the 2019 event in Naples, Italy, May 3-9. The ITA 2019 awards program will be held in the United States, November 2019, in Miami, FL, in conjunction with the UCA Cutting Edge program.

Financial update

David Kanagy reviewed the financial report as of April 30, 2018, which included seven months of the UCA/SME fiscal year. He noted that revenues totaled $1,378,120 with expenses of $544,283 for a surplus of $833,837. The NAT Conference was the largest change from last year's revenue and expenses. Many of the expenses for NAT 2018 were still to be paid and would bring down the overall surplus. Membership and advertising appear to be in line with the budget. He highlighted several costs associated with the actual P&L statement as well as revenue. The UCA should achieve its budget targets for FY 2018. The UCA scholarship fund was $200,720. The scholarship fund will receive a large transfer of funds when the surplus from NAT 2018 is determined. For every fully paid registration, $25 is added to the fund plus 25 percent of the meeting surplus.

UCA membership report

Melanie Penoyar-Perez reported on the UCA membership as of May 31, 2018, which runs on a calendar year basis. Total UCA membership is 1,116, an increase of 145 from the same time period in 2017. This includes 28 corporate and 28 sustaining company memberships. She outlined the activities to recruit and retain members including those at NAT. The corporate and sustaining member reception on June 24 was well attended and appreciated.

Membership initiatives in 2018

- Welcoming new UCA members — A series of five emails introducing the benefits of the UCA to new members (launched).
- Member-Get-A-Member campaign — Most members come to the UCA through referral. This campaign will help current members share the value of membership with peers.
- NAT membership offer — A membership will be provided with nonmember, full-conference registration for the NAT Conference.
- Communicating added value — These are new programs for members, including a branded UCA credit card and discounts on insurance and travel.
- Corporate and sustaining member outreach — Personal outreach to lapsed and potential members will be expanded.

A member-value survey will be conducted in October 2018. This survey occurs every four years. The results will be available at the beginning of 2019.

Membership fees for 2019

Penoyar-Perez detailed the history of the corporate and sustaining membership fees and noted that UCA raised the fees in 2018 for the first time in more than 10 years. Following the policy established by the Executive Committee in 2017, the rates will increase by the cost of living in 2019.

The expected cost for 2019 membership in each category is shown in the chart at right.

Dues Rates	2018	2019
Registered	$ 271	$ 276
Individual	$ 156	$ 159
Associates Under 30/Senior	$ 76	$ 79
Student	$ 32	$ 33
Corporate	$ 900	$ 925
Sustaining	$ 1,800	$ 1,850
DOL CPI Increase	0.028	

UCA leadership directory

Penoyar-Perez distributed and reviewed the UCA leadership directory, which includes all of the UCA boards and committees — membership, positions and terms for each member. It includes the ITA working groups and the committee members from the United States.

T&UC

Bill Gleason reviewed *T&UC* and noted the plans for the 2018 September and December issues. Roach requested that the "Tunnel Demand Forecast" be available online only to members of UCA.

Colin Lawrence, executive committee liaison for *T&UC,* completed his term at the conclusion of the meeting, and Red Robinson was appointed to replace him.

UCA-related books

Roach presented the publishing report and noted the 10 books currently available from UCA/SME on underground construction. Approximately 1,000 copies of the *History of Tunneling in the United States* (HOTUS) have been distributed, and approximately 982 remain in inventory.

Roach provided an update on the revision to *Recommended Contract Practices for Underground Construction*. Several key topics need additional information or updates since its first publication in 2008, including the design-build process that was not included in the previous edition. A workshop with 35 participants was held to outline the proposed changes and to secure feedback prior to the NAT Conference. The book should be ready at the RETC next year in Chicago, IL.

Conference activities

2018 SME Annual Conference & Expo — Tara Davis highlighted plans for two UCA sessions at the 2019 SME Annual Conference & Expo to be held in Denver, CO. One session is scheduled to focus on tunnels and the second session will focus on shafts. Jim McMahon will host the shafts session, and Jamal Rostami will host the tunnels session.

2018 George Fox Conference — Davis reported that the program will be held on Jan. 22, 2019 at CUNY, New York, NY. There are concerns that the conference has outgrown the CUNY center and that it might be time to review other options. It was agreed that, following the changes requested for 2019 by the school, UCA would review the effectiveness of maintaining the program at CUNY.

NAT 2018 — Davis, Lonnie Jacobs, Cori Knasinski each reported on the preliminary outcomes of NAT 2018. 1,155 people attended the meeting, which was the largest number of attendees ever recorded for NAT. Several items identified for improvement included creating more exhibit-only time to visit exhibitors, a review of the conference and exhibit hours on Tuesday and Wednesday and better coordination with events — specifically the owners, Young Tunnelers and Women In Tunneling activities.

Cutting Edge Conference 2018 and 2019 — Goodfellow updated the committee on the status of the Oct. 29-31, 2018 conference in Atlanta, GA. A site visit will include the City of Atlanta Water Pumping Program. Registration will be open soon. Early sponsorship sales were strong, and UCA expects to meet the budget as planned. Goodfellow also reminded the EC that the ITA would hold its annual awards program in conjunction with the 2019 conference. Sites and dates were still being reviewed. Both events would be held in Miami, FL.

UCA Young Members Committee

Demetrico Criscuolo gave an update on recent UCA Young Members (UCAYM) activities. Six webinar programs were completed in the previous 12 months with high-value ratings from the participating Young Members. A UCAYM reception was held during NAT, with 80 in attendance, costing approximately $6,500. A $4,500 sponsorship was donated for the event that was held at an off-site restaurant. This is less costly to the group than the headquarters hotel.

The UCAYM requested $5,000 in support of its activities and for a reception at RETC 2019. If the details have been confirmed by the time the preliminary program brochure is developed, that information can be added to the flyer. The brochure is normally produced about four to five months before the program.

After a brief discussion, it was moved, seconded and approved to support this request for $5,000 in support of the UCA Young Members activities and reception at the RETC 2019 meeting.

Criscuolo reported on the Conference Attendance Scholarship program at NAT. He thanked the Executive Committee for its support and the funds committed to the program in 2016, 2017 and 2018. He highlighted several of the benefits that students received from the program and noted that 38 students received the conference scholarship funds at the NAT 2018 Conference. The UCAYM asked for $50,000 for a similar program at RETC 2019.

It was moved, seconded and approved to accept the recommendation to support a similar scholarship program at the RETC 2019 in the amount of $50,000.

Teach the Professors tunneling course

Mike Mooney held the first Teach the Professors course. Seven professors attended from geotechnical and construction engineering. There were six industry mentors, three for each area, recruited to assist with the questions and answers. Three conference calls prepared the professors for the conference and training sessions during the program. Each professor identified a topic area for underground curriculum development. It was agreed that the impact of this program would be evaluated before a second program was scheduled in conjunction with NAT 2020. Mooney will maintain contact with those who participated and provide a recommendation for a future event.

Scholarship streamlining

Roach introduced a discussion on the three scholarship programs offered by the UCA, both school scholarships and conference program scholarships. RETC also has a scholarship fund and provides a variety of scholarships to the tunneling industry. It was agreed that the UCA should review all of the scholarship programs and that a minimum of three items should be reviewed:

- Review the application process and schedule.
- Improve the marketing efforts to schools.
- Review and modify the criteria as necessary.

UCA will form an ad hoc committee to review this issue consisting of Bob Goodfellow, Mike Rispin, Pam Moran, Mark Johnson, Aaron Clark, Tara Davis and Carol Kiser. This group will provide a report and more feedback at the next meeting.

Marketing program

Paul Schmall reported that Hanson and Baylea had not yet completed its work on the UCA project to engage and promote tunneling to students and other important groups. Schmall agreed to connect with them and determine the status of the project.

UCA/ASCE student chapter activities

Schmall reported that the student chapter program was launched with the ASCE student chapters and five presentations and tours were completed during the last school semester. Funding for the event has been renewed. One of the limitations of the program is knowing what underground projects are available to visit. He asked that anyone interested in hosting an event contact him so that he could make a connection with a student chapter for a future visit.

UCA strategic goals

Goodfellow reported on a visit to Congressman Jack Bergman's (MI-1) office to discuss the tunneling industry and to answer questions he had regarding a potential project in his congressional district. The group presented him with a copy of the HOTUS and other general material on tunneling. This visit was a result of a call to the UCA/SME office prior to the conference and Kanagy arranged the visit. This type of outreach is always possible. Goodfellow asked Brian Fulcher to put a proposal together regarding the distribution of HOTUS that the executive committee could review.

Goodfellow also reported on a discussion with ASCE staff members on their annual Legislative Fly-in Program. UCA is discussing the possibility to "tag-on" to their program and visit congressional members and staff on tunneling-related issues. If ASCE agrees, it would cost UCA about $15,000 and could be started in March 2019 at the earliest. This is being reviewed by ASCE staff, and they will provide an update to UCA in several months.

After brief discussion, it was moved, seconded and approved to support a UCA Legislative Fly-in Program in conjunction with ASCE.

Other business

Owners reception — Roach asked for feedback from those who attended the owners' reception. Overall, it was well received, but only 20 people attended. The owners would like a greater attendance. A different night was suggested. Lonnie Jacobs and Rich Redmond will speak with Ted Downey to determine if there is any interest in holding a similar reception at RETC. It was agreed that UCA will hold the event again at NAT 2020, if the owners feel there is value.

Women in Tunneling — The Women in Tunneling luncheon was very well received. This group has been asked to work within the UCA structure and will bring a plan to the executive committee meeting in January. They would like to develop a logo and begin a few programs for women working at tunneling job sites to attract and maintain younger female professionals in the program and industry.

Following a brief discussion it was moved, seconded and approved to support this group and their efforts with a $5,000 budget for their activities.

NY Engineering Festival — Jacobs reminded the committee that UCA has supported the Engineering Festival with an annual donation of $7,500 each year. This helps more than 4,000 students attend the event to learn about science, engineering and technology and encourages them to explore career opportunities. He noted that this New Jersey/New York program needs additional funding.

It was moved, seconded and approved to increase the UCA donation to $10,000 annually beginning in 2019.

Next meeting

The next meeting of the UCA Executive Committee will be held at the offices of Mott MacDonald Jan. 23, 2019 following the George Fox Conference in New York, NY. ■

ITA

Report on the 2018 World Tunnel Congress and ITA activities

by Randall Essex, Mott MacDonald and ITA Executive Council

The 44th Annual Meeting of the International Tunnelling and Underground Space Association (ITA) was held in conjunction with the World Tunnel Congress (WTC) April 21-26, 2018 in Dubai, UAE. The congress theme was "The Role of Underground Space in Building Future Sustainable Cities." Forty-eight of the 75 member countries were represented and attendance was in the range of 1,700. There were 45 registrants from the United States. The technical program consisted of four parallel tracks with 165 papers presented orally and another 250 presented as posters. A training session was conducted by ITA-CET prior to the congress program.

Cording presents Sir Alan Muir Wood lecture

The highlight of the opening ceremonies was a keynote lecture presented by Dr. Edward J. Cording, professor emeritus at the University of Illinois. Cording, who was selected to give the 2018 Sir Alan Muir Wood lecture, presented "Monitoring and controlling ground behavior at the source — Recent applications of pressurized tunneling." His talk featured many lessons learned from the Alaskan Way Viaduct Replacement Tunnel Project in Seattle, WA. With the increasing role of large diameter machine-mined tunnels globally, Cording's presentation resonated with the international audience. The presentation can be found on the ITA website, https://awards.ita-aites.org.

A team effort

Although the congress suffered some organizational hiccups, the technical sessions were of a high quality in both content and organization. The latter was the result of a lot of hard work on behalf of the appointed session chairs, a number of whom were selected from the U.S. tunneling industry. Thanks to Mike Rispin, Amanda Elioff, Henry Russell, Jon Hurt, Verya Nasri and Mark Johnson for lending their support. Also, thanks to Dave Kanagy and the UCA of SME for providing the pocket guide electronic files from the WTC 2016 to the Dubai Organizing Committee. For accompanying persons, Dubai was found to be a remarkable city, with many interesting sites and experiences, if you exercised some individual initiative.

Raising the bar

The ITA Executive Committee is reviewing lessons learned from the Dubai WTC as well as a number previous WTCs. The writer is leading a task force to develop a *WTC Planning Guide*, which will help newly appointed hosts plan and implement WTCs going forward. The task force is in the final stages of a draft that will be provided to the Naples WTC organizers for their upcoming congress on May 3-9, 2019. The guide will provide minimum standards, guidance points and templates that will facilitate the planning and implementation of these complex international events. Also, the ITA has sent an inquiry to all member nations, soliciting feedback on how the host country should be selected for each WTC. The focus of these ITA initiatives is to improve the quality of the WTC experience for authors, exhibitors, advertisers, delegates and accompanying persons alike.

ITA working groups

The ITA maintains 14 working groups, covering key subjects such as research, advancing equipment and ground support technologies, health and safety, contractual practices, challenging site conditions, applications in urban areas, asset management and the application of building information modeling, BIM, in tunneling projects. Many from the United States serve as animateurs, vice animateurs or key working group participants. The working groups are the heart and soul of the organization and will continue to publish documents through ITA. The list of working groups is on the ITA website, https://awards.ita-aites.org. If you would like to get involved, contact Randall Essex who will connect you with the appropriate animateur (randall.essex @mottmac.com).

International tunneling awards

ITA will host the ITA International Tunneling Awards in Chuzhou/Nanjing, China, on Nov. 3-4, 2018.

There are more than 70 entries for this year's awards. The ITA International Awards for 2019 will be hosted by the United States in conjunction with its annual Cutting Edge Conference in Miami, FL in the fall. ■

EXECUTIVE COMMITTEE

(Continued from page 54)

consulting focuses on analysis, design, construction and monitoring of tunnels, shafts and excavations, and earth dams and levees. He teaches courses in soft ground tunnel design and construction, earth retaining structures and support of excavations, soil mechanics and dynamics, instrumentation and monitoring, and intelligent geosystems. He was the Scientific Committee chair for the 2016 World Tunnel Congress. ■

The UCA of SME

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Their support for the underground construction industry and its professionals is sincerely appreciated.

For more information on these companies and/or UCA of SME membership, visit ***uca.smenet.org***, email us at ***hill@smenet.org*** or call 303.948.4200.

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TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark	NJ	Subway	14,600	24.5	2019	Design study
2nd Ave. Phase 2	NYC-MTA	New York	NY	Subway	16,000	20	2019	Under design
2nd Ave. Phase 3-4	NYC-MTA	New York	NY	Subway	105,600	20	2020-25	Under study
Kensico-Eastview Connection Tunnel	NYC-DEP	New York	NY	Water	10,500	27	2020	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	2022	Under study
Redundancy Tunnel Program - Southern	Boston MRWA	Boston	MA	CSO	50,160	10	2022	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	10,000	30	2018	Under design
Thimble Shoal Parallel Tunnel	Chesapeake Bay Bridge & Tunnel Dist.	Chesapeake	VA	Highway	5,700	45	2016	Dragados/ Schiavone awarded
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 Alexandria	Alexandria	VA	CSO	10,500	20	2021	Under study
Potomac River CSO Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	4,500	33	2022	Under design
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2017	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	 30,000 21,000	 18 14	 2018 2019	 Under design Under design
Westerly Main Storage Tunnel	NEORSD	Cleveland	OH	CSO	12,300	24	2020	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	2022	Under design
ALCOSAN CSO Ohio River Allegheny River Mononghahela River	 Allegheny Co. Sanitary Authority	 Pittsburgh	 PA	 CSO	 10,000 41,700 53,900	 30 30 30	 2019 2020 2021	 Under design Under design Under design
I-75 modernization project	Michigan DOT	Detroit	MI	CSO	22,000	14	2018	Bid date 8/21/2018
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

FORECAST T&UC

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
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	2018	Under study
Northeast Interceptor Sewer 2A	LA Dept. of Water and Power	Los Angeles	CA	Sewer	18,500	18	2014	Delayed indefinitely
River Supply Conduit - Unit 7	LA Dept. of Water and Power	Los Angeles	CA	Water	13,500	12	2015	Frontier-Kemper low bidder
JWPCP Effluent Outfall Tunnel project	Sanitation Districts of LA	Los Angeles	CA	Sewer	37,000	18	2015	Bid date 9/18/ 2018
Two Mile Bar Tunnel	Oakdale Irrigation	Oakdale	CA	Water	5,950	11.5x13	2017	SMCI low bidder
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2016	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	2016	Single tunnel option approved
Silicon Valley Clean Water Tunnel	Silicon Valley Clean Water	Silicon Valley	CA	CSO	17,500	13	2017	Barnard/Bassac JV awarded
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2015	JayDee/Michels/ C&M McNally Low bidder
Highway 401 Rail Tunnel	Metrolinx	Toronto	ON	Subway	580	35x28	2017	EllisDon/Strabag JV awarded
Keswick Effluent Outfall	City of Toronto	Toronto	ON	CSO	11,600	23	2018	Under design
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
Newfoundland-Labrador Fixed Link	Gov. of Newfoundland/Lab	Newfoundland	NL	Transit	56,000	40	2020	Under study
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	Proposals submitted
Annacis Island Outfall	City of Vancouver	Vancouver	BC	Water	8,000	10	2017	Bid date 9/13/2018
Burnaby Mountain	Kinder Morgan	Vancouver	BC	Oil	8,000	12	2017	Under design
Broadway Sky train extension	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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ADVERTISING SALES OFFICES

HOOPER JONES
CENTRAL, NW U.S.
+1-847-486 -1021
Cell: +1-847-903-1853
Fax: +1-847-486-1025
hooperhja@aol.com

SHERRI ANTONACCI
EAST, SOUTH, WEST U.S.
+1-267-225-0560
Fax: +1-215-822-4057,
smesherri@gmail.com

DARREN DUNAY
CANADA
+1-201-781-6133
Cell: +1-201-873-0891
sme@dunayassociates.com

EBERHARD G. HEUSER
EUROPE
+49 202 2838128
Fax: +49 202 2838126
egh@heusermedia.com

PATRICK CONNOLLY
UNITED KINGDOM
+44 1702-477341
Fax: +44 1702-177559
patco44uk@aol.com

KEN GOERING
INTERNATIONAL SALES
+1-303-948-4243
Fax: +1-303-973-3845
goering@smenet.org

Business Office

SME - 12999 E. Adam Aircraft Cir.,
Englewood, CO 80112 USA
+1-800-763-3132 • Advertising: x243
Direct: +1-303-948-4243
Fax: +1-303-973-3845
www.smenet.org

EDITOR
Steve Kral
kral@smenet.org

SENIOR EDITOR
Bill Gleason
gleason@smenet.org

PRESS RELEASES
Steve Kral
kral@smenet.org

ADVERTISING AND PRODUCTION/ MEDIA MANAGER
Ken Goering
goering@smenet.org