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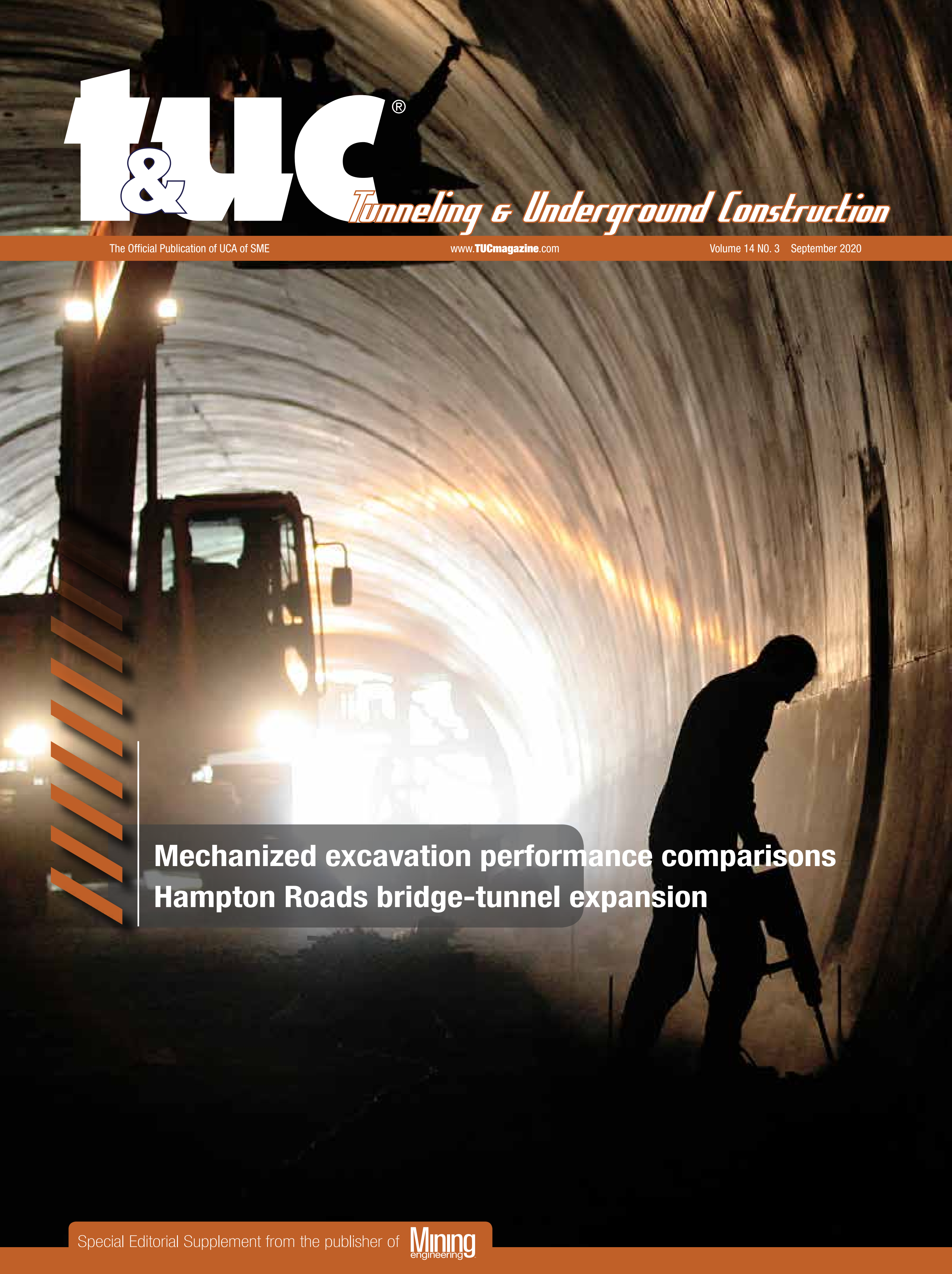

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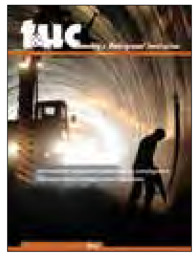

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Special editorial section from the publisher of Mining Engineering

COVID-19 creates challenges and opportunities for UCA members

As the craziness of 2020 rolls on, our industry continues to suffer from delayed project starts and slower procurement schedules across the country. There have been bright spots though. One of these is the recognition that our industry's work is critical and therefore was not stopped due to the COVID-19 pandemic.

One of the most visible signs of COVID-19 impact on our industry is the cancellation or postponement of in-person conferences and events. There has been a lot of chagrin surrounding the postponement and then cancellation of the in-person WTC in Malaysia. The decision by the Institution of Malaysian Engineers (IEM) to not provide full refunds has added to this disappointment. UCA is lobbying hard to both the IEM and the International Tunnelling Association (ITA) to provide full refunds to all those who registered early or provided sponsorship and/or purchased exhibition space. The situation is difficult and frustrating, but we hope that full refunds will be forthcoming eventually.

While the opportunities for in-person networking and publishing of papers at conferences is not possible at the moment, the opportunities for interaction and publishing of industry guideline documents have never been better. The UCA initiative for gathering groups in the United States that work together in support of ITA working group objectives is gathering

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Working Group number	Subject matter for research	U.S. lead point of contact for WG
WG 2	Research	William Hansmire
WG 3	Contractual practices in underground constrution	William Edgerton
WG 5	Health and safety in works	Open position
WG 6	Maintenance and repair of underground structures	Henry Russell
WG 9	Seismic effects	Conrad Felice
WG 11	Immersed and floating tunnels	Christian Ingerslev
WG 12	Sprayed concrete use	Grover Vargas
WG 14	Mechanization of excavation	Brian Fulcher
WG 15	Underground and environment	Open
WG 17	Long tunnels at great depth	Lok Home
WG 19	Conventional tunneling	Nasri Munfah
WG 20	Urban problems – underground solutions	Open
WG 21	Life cycle asset management	Jim Brady
WG 22	Information Modelling in Tunneling	Mark Johnson
WG 23	Design and construction of shafts	Verya Nasri, Mike Wongkaew
Young Member	ITA Young Member Group	Vojtech Gall Jr.

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New York's MTA announces $90 million plan to repair tunnels damaged by Sandy

New York's Metro Transit Authority (MTA) said it will use aspects of Gov. Cuomo's L train tunnel repair plan to fix another East River crossing damaged by Hurricane Sandy.

Transit officials announced plans to ink a $90 million contract to rehab the Rutgers Tube, which connects the F train between the Lower East Side in Manhattan to DUMBO in Brooklyn.

It's one of nine East River subway crossings damaged by Sandy in 2012 and the last one to be repaired.

The New York Daily News reported that the MTA said the tunnel will be fixed by the end of next March — an aggressive timeline made possible by a strategy ironed out during the L train project.

Rather than replacing the bench walls, crews will repair them. And as with the L project, new cables will be installed.

The original plan to replace the L train tunnel's bench walls would have required service to close on the line between Manhattan and Brooklyn for at least 15 months. The cable-repairing idea, announced by Cuomo in January 2019, four months before construction was set to begin, required a service shutdown on nights and weekends for 12 months.

Most of the F train work will also be performed on nights and weekends, said Metropolitan Transportation Authority chief development officer Janno Lieber.

Lieber said the bench walls in the F train tunnel are not damaged as badly as those in the L train tunnel, which will make the work easier.

Crews installed shells made out of fiber-reinforced polymer, or FRP, in damaged sections of the L train tunnel to keep the structure safe in case passengers are required to use it as an emergency walkway. Lieber said concrete adhesive patches will be used to shore up the F train's bench walls.

"All we have to do is spot repairs," said Lieber. "We don't even need to install FRP in places. It's an even simpler version of what you saw

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All four TBMs currently working on Melbourne Metro Tunnel project

Melbourne, Australia's $11 billion Melbourne Metro Tunnel project reached a significant milestone in May when the fourth and final tunnel-boring machine was launched.

The final Herrenknecht mixshield tunnel boring machine (TBM), named Alice, was launched from the Arden site in North Melbourne, putting all four machines to work on the project's 9-km (5.6-mile) long twin tunnels across Melbourne.

It's a big milestone for the Metro Tunnel project that is being constructed by the Cross Yarra Partnership (CYP) consortium, comprising Lendlease Engineering, John Holland, Bouygues Construction and Capella Capital. Work is continuing at all sites in accordance with strict safety measures through the COVID-19 pandemic.

The first TBMs, Joan and Meg, were the first to launch, in 2019, and completed the 1.2-km (0.75-mile) stretch of twin tunnels from Arden to the western tunnel entrance in Kensington earlier this year.

Pieces from the TBMs were returned to Arden Station by truck with the rest of the TBMs, which were pulled back through the tunnels and reassembled.

TBM Joan was relaunched in May from Arden toward the site of Parkville Station, and TBM Meg, after all essential checks were completed, was relaunched.

This is in addition to the significant progress made across the entire project. At Parkville Station, excavation of the station box Grattan Street is now complete, while at State Library Station 50 steel columns are being installed.

The Metro Tunnel is on track to be completed by 2025 — a year ahead of schedule. It will allow more trains to run to the suburbs and reduce travel times by running the busy Cranbourne, Pakenham and Sunbury lines through a new tunnel under the City Center.

The Metro Tunnel will create a new end-to-end rail line from Sunbury in the west to Cranbourne/Pakenham in the southeast, with high-capacity trains and five new

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Klug Construction Systems named new distributor of Nittestsu SuperFine Cement

Klug Construction Systems LLC (KCS) is pleased to announce a new affiliation with the Nittetsu Cement Co. Ltd., whereby KCS will be the distributor of record for the supply of Nittetsu SuperFine ultrafine cement to the North American geotechnical and underground heavy construction markets. The Nittetsu SuperFine ultrafine cement is recognized worldwide for its quality and jobsite performance in solving complex grouting problems.

Nittetsu SuperFine ultrafine cement has a proven track record of more than 25 years in the North American geotechnical and underground heavy-construction markets under the guidance and professional efforts of the management of Surecrete Inc. KCS will continue and plans to build upon the work done by Fred Sherrill and Jeff Stokke of Surecrete Inc. in solving complex industry problems using this specially formulated high-quality ultrafine (≤10 micron particle size) cement. The cement is available in 20-kg (44-lb) bags or 1-t (1.1-st) super sacks.

All quotes, purchase orders, invoices and other commercial activities will be coordinated from KCS offices near Pittsburgh, PA by Jonathan Klug, vice president at KCS.

Nittetsu Cement Co. Ltd. offers engineering consultation services to address specific technical issues and/or for the submittal of applicable test reports. Stokke has been retained and will be available for consultation on technical matters.

KCS has an international Broker of Record that along with the trading company of Nittetsu Cements Co. Ltd. can coordinate all ocean freight shipments to any project site and/or warehouse in North America. KCS will be warehousing the Nittetsu SuperFine cement in the greater Seattle, WA area to meet LTL project requirements. ■

DFI announces 2020 Outstanding Project Award winner

The winner of the 2020 Deep Foundations Institute (DFI) Outstanding Project Award (OPA) is the team of Langan Engineering and Environmental Services (geotechnical and environmental services), Malcolm Drilling Company (foundation contractor), and Condon-Johnson & Associates (shoring contractor) for the innovative foundation design of the Chase Center in San Francisco, CA. The award is being presented during the DFI 45th Annual Conference on Deep Foundations, Oct. 13-16, 2020.

Chase Center, the new home of the Golden State Warriors, covers four city blocks and will provide seating for 18,000 fans, as well as 58,000 sq ft (5,388 m^2) of office/lab, event space, retail, restaurants and underground parking.

The Chase Center is being developed in the Mission Bay area, which has poor ground conditions. A tidal cove thousands of years ago, the area was built up in the early 1900s from thousands of cubic yards of sand, rocks, dirt and debris that came from the 1906 San Francisco earthquake. Besides the engineering and construction challenges that process entailed, the team had to excavate as deep as 30 ft (9.1 m) to fit all the programming on site.

The unprecedented depth and size of the excavation presented challenges with dewatering, maintaining a stable subgrade and supporting the excavation. In addition, the foundation conditions varied significantly across the site, with bedrock as shallow as 30 ft (9.1 m) and as deep as 130 ft (39.6 m).

According to Lori Simpson, P.E., P.G. and vice president of Langan, the company that provided geotechnical, environmental, dewatering and civil excavation consulting services on the project, "Our team provided innovative solutions for foundations, cutoff wall design, soil treatment and dewatering system design."

This year, DFI is also awarding two Special Recognition Awards. The recipients are: Schnabel Engineering, which submitted a project at West Virginia's Yeager Airport, where a team stabilized and restored the safety area for Runway 5; and Mueser Rutledge Consulting Engineers for rehabilitating New York City's Canarsie Tunnel for the L Line subway due to Superstorm Sandy damage, including tunnel feature upgrades.■

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Dugway Storage Tunnel completed $4.6 million under budget

The Northeast Ohio Regional Sewer District has completed work on the Dugway Storage Tunnel, the second of seven tunnels to store combined sewer overflows and keep sewage from polluting Lake Erie.

The Dugway Storage Tunnel was completed at $4.6 million under budget according to a release from the sewer district. The announcement came on the 51st anniversary of the Cuyahoga River fire.

The work is part of Project Clean Lake, the Sewer District's 25-year, $3 billion program to drastically reduce the amount of combined sewage entering local waterways during heavy rain storms.

Cleveland.com reported that the earliest sewers in Northeast Ohio were built around the turn of the 19th century and carry sewage, industrial waste and stormwater in a single pipe. During heavy rains, the pipes overflow into waterways like Lake Erie and Euclid Creek to prevent urban flooding.

In 1972, nearly 9 billion gallons of raw sewage was discharged into the local water bodies. Through decades of investment, the Sewer District

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Dugway is the second of seven tunnel projects that will reduce Lake Erie pollution.

Tunnel dispute delays the world's fastest railway in Japan

Japan's $84 billion maglev project that would link Tokyo and Osaka could be held up by a dispute over a 9-km (5.6-mile)-long tunnel that needs to be built beneath the mountains of Japan's southern Alps for the project to be completed.

Work on the project began in 2014, but the governor of Shizuoka prefecture is refusing to allow work on one short stretch, as he has said the tunnel will divert water out of Shizuoka's rivers. The *Financial Times* reported that the dispute could cost of billions of yen to the JR Central railway. The company's chief executive Shin Kaneko begged governor Heita Kawakatsu to let work begin at an unusual summit that was streamed live to the public.

"It takes time to build such a long tunnel. This is almost the last minute," said Kaneko on July 3, explaining that it would take five years to dig the tunnel and another two to lay the tracks and run tests before the first stage from Tokyo to Nagoya is due to open in 2027. "We need to find some way to keep the work going."

But Kawakatsu gave little sign he will relent, saying the tunnel will divert water out of Shizuoka's rivers, risking long delays to a prestigious national project backed with trillions of yen in public money by prime minister Shinzo Abe.

"Of course we are not against the maglev project itself," said Kawakatsu. "But the towns in the watershed, the people of Shizuoka and everybody in Japan who relies on well water are thinking the same thing, which is what happens if the water is diverted."

The result of decades of research, Japan's maglev uses electrical current to generate a magnetic field, lifting the train by about 10 cm and propelling it forward. Eliminating moving parts and friction allows the train to achieve record speeds. The technology has been used for Shanghai's airport railway but never for an intercity route.

The Shizuoka stretch is part

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Breakthrough at the Brenner Base exploratory tunnel

Crews working on the Brenner Base Tunnel, the world's longest underground rail tunnel linking Austria and Italy, celebrated the completion of the 16.7-km (10.4-mile) long exploratory tunnel on July 6.

The tunnel that connects two Austrian segments forms a continuous 36-km (22.3-mile) tunnel beneath the Alps between Tulfes and Schmirn — around 65 percent of the tunnel's 55 km (34 mile) projected length. The Herrenknecht tunnel-boring machine, nicknamed Günther, drilled from north to south through the remaining quartz phyllite rock near (and below) the town of Steinach am Brenner, Tyrol. The machine is one of a total of six tunnel-boring machines that international construction joint ventures have ordered from Herrenknecht AG in Schwanau, South Baden, for the new world-record project.

The exploratory tunnel is a unique feature of the project. The tunnel is located 12 m (40 ft) below the twin-bore tunnel and will be 61 km (38 miles) long. It is currently used for exploration of the rock and the construction logistics. Upon the completion of construction, the tunnel will be used for drainage and maintenance.

Construction has been divided into four lots, with two in Austria and two in Italy.

The tunnel is currently scheduled for completion in 2025, with the milestone of half of all total tunneling completed in December 2019. The tunnel will open to rail traffic in 2028. Upon completion, it will connect to the existing Innsbruck bypass tunnel to create a continuous 64-km (40-mile) tunnel — the longest in the world.

The Brenner Base Tunnel is a collaborative project between Austria, Italy and the European Union, with both countries contributing roughly 30 percent of the estimated €8.7 billion cost, and the European Union contributing the remaining 40 percent.

The tunnel will be electrified at 25kV ac, rather than the 15kV ac used in Austria, or 3kV dc in Italy, and will be equipped with ETCS Level 2.

The tunnel is intended to address a significant bottleneck on

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New York: MTA sets speedy timeline for repairs

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in (the L train tunnel).”

The project also includes a rehabilitation of the East Broadway stop on the F line, which is scheduled to be finished by next Feb. 16.

The speedy timeline will allow the MTA to get to work on upgrading the outdated signal system that directs A, C and E trains beneath Eighth Avenue in Manhattan in 2021. Transit officials will need the F train tunnel to redirect A and C trains in lower Manhattan and Brooklyn in order to close tracks for the upgrades.

“The L project demonstrated that the MTA can deliver major projects much faster and at less cost,” said Lieber. “We hope we’re starting to make believers out of some people.” ■

Melbourne: Network to expand by 504,000 passengers

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underground stations.

Some of Melbourne’s busiest metropolitan train lines — Sunbury, Cranbourne and Pakenham — will run exclusively through the new tunnel. By taking these lines out of the City Loop, other lines will be able to run more services.

As a result, capacity will be created on the network to enable 504,000 more passengers to use the rail system during each peak period.

The Metro Tunnel is the first step toward a metro-style rail network for Melbourne with the “turn-up-and-go” train services that are the hallmark of the world’s great cities such as London, New York, Hong Kong and Singapore.

The Metro Tunnel Project is fully funded and was procured as a multibillion-dollar availability-based public-private partnership that includes the design and construction of the twin 9-km (5.6-mile) tunnels and five underground stations, private finance and the provision of maintenance and other services during the operating term.

The 2016-2017 budget committed $2.9 billion over the forward estimates to advance construction of the project. ■

Dugway Storage Tunnel: Project Clean Lake continues

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reduced the volume to 4.5 billion gallons. At the conclusion of Project Clean Lake, the Sewer District will have reduced discharges to 500 million gallons.

"Today marks 51 years since the 1969 Cuyahoga River fire, an event that was the catalyst for environmental change, including the need for investing in our sewer and stormwater infrastructure," said sewer district CEO Kyle Dreyfuss-Wells. "Since our creation in 1972, the Sewer District has been committed to that effort, investing nearly $5 billion in sewer and stormwater infrastructure designed to protect public health and the environment. Project Clean Lake further reflects the commitment we have to our region, our customers and the environment, and we look forward to continuing this work for the next 50 years and beyond."

The Euclid Creek Tunnel was the first tunnel constructed under Project Clean Lake. Along with Dugway Storage Tunnel and the Easterly Tunnel Dewatering Pump Station, which pumps sewage to the Easterly Wastewater Treatment Plant, it represents a $416 million investment in clean water. The system will reduce the amount of raw sewage discharging into the environment during heavy rain events by 720 million gallons each year.

The massive Dugway runs nearly 5 km (3 miles) under the Glenville neighborhood, with a pump station located in Bratenahl, just south of I-90.

Project Clean Lake is scheduled for completion in 2035. The remaining four tunnels include the Doan Valley Storage Tunnel, the Westerly Storage Tunnel, the Shoreline Tunnel and the Southerly Storage Tunnel. ■

Brenner Base: Six TBMs will bore the world's longest tunnel

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the Scandinavian-Mediterranean Freight Corridor linking Norway, Sweden, Denmark, Germany and Italy, which travels via the Brenner Pass through the Austrian Alps. The current Alpine railway route causes significant delays to rail traffic and has limited rail's modal share of total freight traffic along the corridor to only 29 percent, compared with the 71 percent held by road freight.

"Currently, 72 percent of goods are transported by truck. This results in 2.5 million truck journeys a year over the Brenner Pass. The Brenner Base Tunnel means a shift from the truck to the rail," said Leonore Gewessler, Austria's federal minister for climate protection, environment, energy, mobility, innovation and technology. "This is not only good news for the climate, with significant CO_2 reductions, but also for the people in Tyrol, because we will be able to increase the number of freight trains from 66 to 225 per day. ■


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First of two tunnels for the Regional Connector Transit Corridor completed in Los Angeles

The area below ground in Los Angeles, CA is the scene of state-of-the-art engineering achievements. German high-tech tunnel-boring machines (TBM) from Herrenknecht are creating underground arteries for the city. One TBM, named Harriet, successfully completed her drive for the Crenshaw/LAX Transit Project in April 2017. A second TBM, named Angeli, finished digging the first of two tunnels for the Regional Connector Transit Corridor on July 18. From spring 2018 onward, the tunnel-boring stars will have additional company: for each of the Purple Line Extension Sections 1 + 2, two more Herrenknecht TBMs will be working their way through the difficult ground. All three projects are part of the strategic subway extension in Los Angeles to relieve the traffic above ground.

Los Angeles suffocates in traffic during rush hour. For this reason

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Herrenknecht machines have bored two tunnels for the Crenshaw/LAX Transit project in Los Angeles, CA.

Breakthrough: Work will continue in Los Angeles

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the Los Angeles Metropolitan Transportation Authority (Metro) is pushing ahead at full speed with the expansion of local transport links. In the coming years, the existing metro rail network will be expanded in a number of different places. The latest example is the Crenshaw/LAX Transit Corridor. The nearly 14-km (8.7-mile) long new light rail route will improve the connection between the urban centers of Crenshaw and Inglewood as well as the region around Los Angeles International Airport (LAX). LAX passenger numbers alone show the high demand for public transport capacity: in 2016, more than 80 million passengers were processed — and the trend is rising.

Between May 2016 and April 2017, Harriet worked its way forward underground for a section of the Crenshaw/LAX Transit Corridor. The TBM (6.51 m or 21 ft) first excavated a 1.6-km (1-mile) long tunnel between the future stations of Expo/Crenshaw and Leimert Park. It was then disassembled and transported back to the launch shaft for the second, parallel section. In April 2017, Harriet, completed her mission below Los Angeles with the second breakthrough in the target shaft at the Leimert Park station. With a 24-hour best performance of 43 m (141 ft) a new record in mechanized tunneling with a subway-sized EPB Shield was set for the city of Los Angeles — four more times, 40 or more meters were created within one day. Thanks to weekly best performances of 170 m (557 ft), the Crenshaw/LAX Transit Corridor was expected to go on line on schedule in 2019.

In February 2017, the EPB named Angeli got under way. The TBM is boring a section of the Regional Connector Transit Corridor. It will link the existing Gold, Blue and Expo Metro Lines to new and faster direct connections. From 2020, this will allow locals and visitors to travel north-south from Azusa to Long Beach and east-west from East Los Angeles to Santa Monica without having to change. Angeli has just finished the first of two 1.7-km (1.1-mile)-long tunneling routes. On July 18, she reappeared in the target shaft at 4th Street. Next she will dig a parallel tunnel with the final breakthrough scheduled for the end of the year.

One of the greatest challenges in mechanized tunneling under Los Angeles is the possible gas deposits. In order to master these safely, the contracting joint ventures have opted for special technology from Herrenknecht. The electrical components in Harriet and Angeli are explosion-protected so that safe tunneling can be realized at all times. This measure has previously proved its worth worldwide in various reference projects.

In the meantime, designers and engineers at the Herrenknecht headquarters in Schwanau are already working on the next order for Los Angeles. The existing Purple Line is also planned to grow by 14.5 km (9 miles) and seven stations. To this end, in both the spring of 2018 and the spring of 2019, two additional Herrenknecht EPB shields each were to be launched. In just a few years the four machines will produce more than 11 km (6.8 miles) of high-quality tunnel tubes. A decade ago, under similar conditions, two EPB Shields from Herrenknecht had already built a total of 4 km (2.5 miles) of tunnel for the expansion of the Gold Line. ■

Japan: Dispute threatens tunnel project

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of the 25-km (15.5-mile) Minami Alps tunnel, the deepest built in Japan, with 1,400 m (4,600 ft) of mountain above it. The tunnel will start in neighboring Yamanashi prefecture and go all the way through the mountain range to Nagano prefecture.

Because the tunnel slopes downward to both exits, Shizuoka prefecture fears it will drain ground water that would otherwise enter the Oi river. "We want them to pump the water back," said Yasuhiro Oribe, director of environmental protection in the prefectural government.

JR Central insists it is taking the water problem seriously and will follow the advice of an expert panel convened by the national government, but commentators say it has underestimated the prefecture's concerns.

"The biggest problem is that this railway has no benefit for Shizuoka prefecture. For them, it's a risk without a return," said Naoki Osaka, a reporter for *Toyo Keizai* magazine who has been following the dispute.

Whereas every other prefecture on the route will get a station, connecting it to Tokyo and Osaka in minutes, Shizuoka will get nothing. What is more, the new maglev — known as the Chuo or Central Line — will bypass the existing Tokaido high-speed line, which runs along the coast through Shizuoka's main cities and is also run by JR Central.

Osaka has suggested that what Shizuoka would really like is a new station on the Tokaido line at its prefectural airport. But having pushed so hard on the environmental issue, and with a possible re-election campaign due next year, it would embarrass Kawakatsu to cut a backroom deal.

Since there is no other way to build the maglev, local observers think the prefecture will eventually give the go-ahead, but pressure is on JR Central.

"The 2027 schedule doesn't have any slack built in; it was extremely tight from the start," said the company, which is building the project at its own risk, albeit with the help of low-interest government loans. "If this situation continues, then we fear there could be an effect on the opening date." ■

UCA advocates for members in WTC cancellation

by William Gleason, Editor

All of the in-person conference aspects of the 2020 World Tunnel Conference (WTC) that were scheduled to take place in Kuala Lumpur, Malaysia, Sept. 11-17 were cancelled by organizers because of the COVID-19 pandemic. This news came as little surprise to those who had already registered. However, what likely was a surprise to most was the notification from the Institution of Engineers, Malaysia (IEM), the host organization of the conference, that those who had registered would not be receiving full refunds.

The UCA, a division of SME, acting on behalf of its members, responded to the IEM as well as the International Tunnelling and Underground Space Association (ITA) with a series of letters demanding full refunds.

For WTC events ITA serves as a sponsor, but the host nation organizes and runs the conference, including all contractual and financial arrangements with the venue, associated dinners, receptions and tours, and processing all sponsorships, exhibits and registration fees. The host stands to gain the most while also assuming the most risk should something go wrong, like a global pandemic. According to Randall Essex, an ITA vice president on the Executive Council (ExCo), the ITA has no involvement with the revenues received by IEM. Nevertheless, ITA's ExCo reviewed IEM's financial position and has urged IEM to offer the largest refund possible.

As of Aug. 5, the IEM has agreed to refund about 70 percent of funds received which includes about 8.5 percent contributed by the ITA by waiving its congress fees.

Essex told *T&UC* that based on its review, ExCo is of the opinion that IEM can afford to and should increase its level of refund. In the spirit of transparency to its constituents, ITA has invited IEM to present its financial accounts at the virtual General Assembly in September and explain why only a limited refund is being offered.

IEM has recently issued two notices that have made the refunds conditional to additional processes; one includes a sign off that refunds will be accepted in full, in effect waiving any further action on behalf of the participants/exhibitors/sponsors, and another requiring authors to create and provide to IEM a presentation video. Neither notice was sent with ITA's knowledge or approval.

For its part, UCA has continued to push for a full refund for its members.

Robert Goodfellow, current chair of the UCA, and David Kanagy, executive director of SME, penned the letters to the IEM and ITA on behalf of UCA members.

"It is not right or fair that

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Chairman's Column: This is a good time to get involved

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momentum. The UCA representatives to each working group are shown in the table (page 2) for your reference.

You will note when you read the table that three key leadership positions are vacant and waiting to be filled. Perhaps by you? If you feel like you have the expertise and interest to lead this effort and want to connect with the ITA, please let me know, as we intend to fill these slots in the coming weeks and months from those who express an interest.

The leaders identified in the table (page 2) have been tasked with filling out a small but active group of three to five people, including one young member and one member of the Women in Tunneling group of UCA. Please do not hesitate to step forward and take this opportunity and get your name on an industry publication. We are always keen to see more volunteers, and I am happy to introduce you to any of the group leaders in your area of interest.

One final thought. If you have any ideas for a document or area of tunneling that could benefit from an industry position paper or guideline, or if you just want to get involved but don't know how, please get in touch. I will gladly identify an outlet for your energy, where you can contribute to the well-being of the industry and raise your own profile in the process. ■

Robert Goodfellow
UCA Chairman

WTC: ITA will evaluate future conferences

(continued from page 26)

those who registered early, purchased booths and committed to sponsorships in some way are stuck for the cost of an event that was not held. This precedent is also anticipated to have a negative impact on future WTC events by encouraging prospective attendees to postpone participation decisions to avoid such future situations," Goodfellow wrote in a letter to ITA and IEM on July 16. "We ask that you reconsider your decision and refund 100 percent of all fees paid by everyone. We recognize that this is a financial burden to both ITA and IEM, but this burden would be easily mitigated by moving forward with a WTC in Malaysia in 2022 as has already been offered."

In June, the UCA was forced to cancel the in-person aspects of the North American Tunneling Conference in Nashville, TN and instead pivoted to put on a virtual meeting with 26 sessions and a virtual exhibit floor. For those attendees and exhibitors who had committed to the conference long before the COVID-19 pandemic, the UCA offered full refunds or the ability to apply funds to a future conference, including RETC scheduled for June 13-16 in Las Vegas, NV.

"I was surprised and disappointed that it wasn't a 100 percent refund from IEM," said Goodfellow. "That is how SME did its business when we had to cancel NAT, and we understand the issues of cancelling a conference. But not offering a refund is not appropriate. We will continue with our efforts to get a 100 percent refund for our members."

Essex said that well before the COVID-19 pandemic, ExCo was evaluating the merits of changing how future WTC events could be

NAT Week: A virtual experience adapts to provide valuable professional development online

by Margo Ellis, Associate Editor

NATWEEK
A VIRTUAL EXPERIENCE
NORTH AMERICAN TUNNELING CONFERENCE

During the initial chaotic weeks of the nationwide lockdown and COVID-19's reality check on life as we knew it, the UCA, a division of SME, was forced to make the difficult decision to cancel the planned biennial NAT 2020 Conference that was to be held in Nashville, TN. With determination and ingenuity in a time of great uncertainty, however, the UCA staff and program committee quickly pivoted and threw its efforts behind a new variation, NATWeek: A Virtual Experience.

Held online June 8-12, 2020, the North American Tunneling conference-turned-virtual-experience was a weeklong program designed to share some of the much-anticipated technical programming from NAT 2020. With all things online in this new high-tech format, the event also included a virtual tradeshow that included 115 participating industry exhibitors that supplied 211 pieces of collateral in the form of white papers, brochures, press releases and video links that are still available at virtual.natconference.com.

Many of the scheduled speakers from the planned in-person conference spoke at the virtual event that centered around four main tracks: technology, design, planning and case studies. Not unlike the in-person conference, registrants were able to take full advantage of hearing from tunneling industry experts as they presented on current projects, best practices and successes throughout North America. With the preparation and legwork of having all the necessary components and "meat" of the conference done and ready, the work transitioned to making the content available virtually through a mixture of both recorded and live presentations — 26 in all were shown throughout the week.

Tara Davis, content development and program director at SME, explained, "Our main goal was to provide a nice representation of the fuller program that would have been available at the conference. In a time of needing to adapt quickly, we were eager to provide this to our members in as seamless a way as possible. The heart of the program was still the same and the high-quality content our members have come to expect from us, but it was just delivered differently this year. The only substantive difference is that it was smaller."

A sampling of speakers from coast to coast included:

- Highway Connection through Ouachita Mountains — Arkansas Tunnel Studies Eric Wang, HTNB Corp., New York, NY.
- Determining the feasibility of tunneling for flood mitigation after Hurricane Harvey. Brian Gettinger, Freese and Nichols, Houston, TX.
- EPBM proactive tracking and progressive optimization. Elisa Comis, McMillen Jacobs, Mayfield Heights, OH.
- Estimating project contingency reserves — now what? Joe O'Carroll, Mott MacDonald, San Diego, CA.

Other highlights were conference favorites: the owners' forum and tunnel demand plenary session. And to round out the two hours of sessions daily, a live question-and-answer panel spurred some insightful discussion. Weeklong registrants have access to all NATWeek sessions and the eBook proceedings, which includes 90 manuscripts.

For those who didn't attend NATWeek, this content is available in the SME bookstore as individual items for sale or as a package that include the sessions along with the recorded question-and-answer panel discussions. Three options are available:

1. The complete package (best deal) includes all the proceedings from NAT (90 total submissions for the planned in-person conference), all recordings of the 26 sessions and the question-and-answer panel discussions. Price: $299/members, $349/ nonmembers.

2. Each of the recorded sessions are available separately (26 available). Price: $45/members, $90 nonmembers.

3. The entire collection of proceedings as the eBook, which includes everything submitted for the original NAT 2020 Conference; 90 in total. Price: $99/member, $200/nonmember.

These items for purchase are all available at the SME Store at www.smenet.org/store. Using the search tool, enter NAT or NATWeek or click on "Media" in the menu on the left side of the page.

Program committee chair Jon Hurt stated, "While it was disappointing not to see everyone in person, the virtual NATWeek did allow some of the hard work by authors, session chairs/ reviewers and the NAT committee to be put to good use sharing knowledge across the tunneling community. We appreciate the work by SME staff to transform the NAT conference into the online version and the sponsors who supported it."

Those valued sponsors for this virtual experience were Jennmar Civil, Herrenknecht Tunnelling Systems, DSI Underground, Gall Zeidler Consultants, Jacobs, SAK, Walsh, McMillen Jacobs Associates, Traylor Bros Inc., BabEng, Louvsuns and Skanska.

Another resource from the UCA of SME for timely pandemic-related information is the second webinar featuring tunneling project managers discussing the challenges of working in the industry in the face of a pandemic. A recording of this free webinar, Underground Construction During the COVID Age, Part II, can be found on the UCA of SME site at https://bit.ly/33MRfBY. ■

The Boring Company releases plans for its "Not-A-Boring Competition"

Since its inception, the Boring Company, the tunneling part of Elon Musk's array of companies that includes Tesla and SpaceX, has been a unique venture and now it is issuing a challenge to the public to compete in a tunnel-boring competition. The challenge has been dubbed the first "Not-A-Boring Competition."

"Teams will compete to bore a 30-m (98-ft) tunnel with a cross-sectional area of 0.2 m^2 (2.1 sq ft)," the company wrote on its website. "Winning categories will include the fastest to complete a tunnel, the fastest to complete a tunnel and a driving surface that a remote-controlled Tesla can navigate and the most accurately bored or on-target tunnel."

The Boring Company has a completed test tunnel in Hawthorne, CA. It is currently in construction on the Las Vegas Convention Center Loop and is in the permitting phase for a project in Los Angeles, CA and the Washington, D.C. to Baltimore Loop.

"The Boring Company's goal is to build the tunnel infrastructure necessary to enable fast, safe and comfortable transportation, including Loop and Hyperloop. To feasibly build a large network of tunnels, one must first rapidly innovate to increase tunneling speed and reduce tunneling costs," the company said on the release.

In promoting the contest, the Boring Company said it is challenging teams to come up with tunneling solutions and answer the question, "Can you beat the snail?"

"The Boring Company is gauging interest from everyone (students, companies, hobbyists, etc.) from around the world to design, build and race their own tunneling solution at The Boring Company's Dig-a-Factory in the first Not-a-Boring Competition in spring 2021."

The Boring Company grew out of Musk's ambitions to revolutionize both inter- and intra-city transit using his Hyperloop and Loop designs. Hyperloop is Musk's near-supersonic tube transport that he open-sourced and a few startups have taken up developing. Loop is an underground system of tunnels that would allow commuters to bypass traffic by getting whisked beneath it on sleds moving at up to twice the speed allowed on the freeway.

As the above concepts rely on being able to bore a whole lot of tunnels, the Boring Company was born.

A demonstration tunnel has been completed at SpaceX headquarters in Hawthorne, CA, and more recently the company has been digging tunnels beneath the Las Vegas Convention Center that could open for use during conferences next year, if we ever have conferences again, that is.

Overall, though, the promise of Loop and Hyperloop have been largely unrealized. The Boring Company is hoping that some old-fashioned competition and camaraderie among ambitious innovators might change that. First, though, it's just collecting a list of potential teams from schools and companies around the world to see if there's actually enough boring interest. ■

Mechanized excavation in shale formation; Performance comparisons at the Doan Valley Project

Excavation performance is a term used in underground construction to describe the influence of several parameters on the cutting rate of mining machinery. The main factors affecting the excavation performances are:

- The geology (rock and rock mass mechanical properties and conditions).
- The process (in terms of operation, maintenance, logistics).
- The methodology (the type of machine, tools and ground support chosen).

The Doan Valley Project represents a unique scenario where, within the same geological features and operational boundaries, different excavation methodologies have been successfully implemented and can now be evaluated for the performance achieved:

- The 3.6-m (12-ft) main-beam tunnel-boring machine (TBM) for the total 9,170 linear feet (LF) (2,795 m) of Woodhill and Martin Luther King Jr. Conveyance Tunnels (respectively, WCT and MLKCT).
- The roadheader for the excavation of the total 520 LF (158 m) of the Doan Valley Storage Tunnel (DVT) Starter Tunnel (ST), MLKCT starter tunnel and tail tunnel.
- The 6.4-m (21-ft) single shield TBM for the 9,670 LF (2,956 m) of DVT.

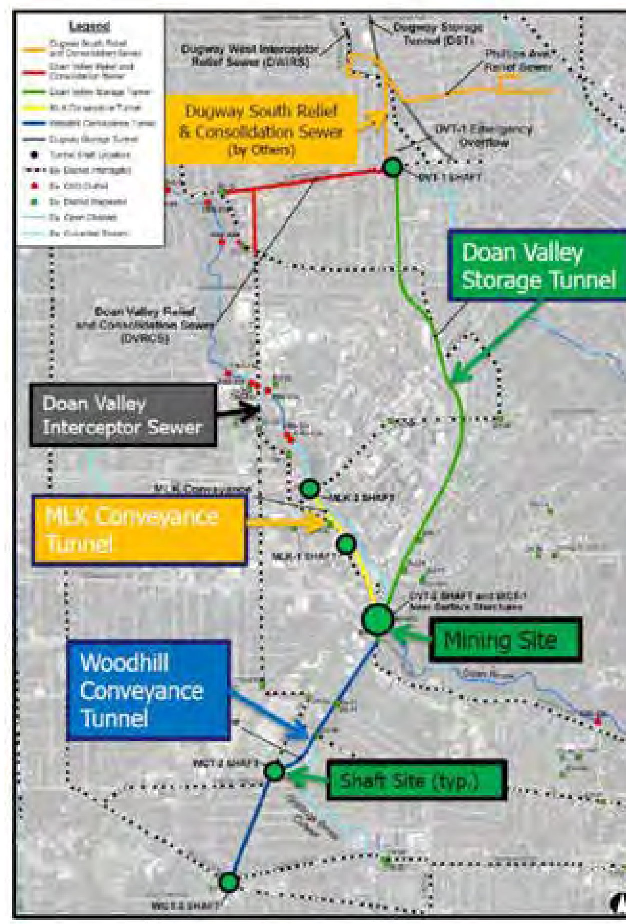
Given the same geology and process, this article will analyze and quantify the efficiency of each methodology based on the results achieved versus some of the assumptions made at the estimating stage.

The NEORSD program and the DVT project

Located in the cultural center of the University Circle neighborhood on the east side of Cleveland, OH, Doan Valley is a major component of the Northeast Ohio Regional District's (NEORSD) Project Clean Lake program, a $3-billion, 25-year program with the ultimate goal to ensure 98 percent of wet weather flows entering the combined sewer system receives treatment, thereby drastically reducing raw sewage discharge into Lake Erie and associated waterways. As part of the Easterly Service CSO discharge area, the annual combined sewer overflow (CSO) capture for the Doan Valley Project is 365 MG/year through three tunnels ranging from 2.6 to 5.5 m (8.5 to 18 ft) finished diameter and six tunnel shaft sites with associated near-surface sewer structures. On April 6, 2017, McNally/Kiewit DVT Joint Venture (MK DVT JV) was awarded the DVT contract by the NEORSD for $142,320,000. Construction commenced on July 10, 2017.

FIG. 1

Doan Valley Project layout.



Martino Scialpi, Karrie Buxton and Brian Negrea

Martino Scialpi, member UCA, was tunnel manager, Kiewit Infrastructure Co.; Karrie Buxton, member UCA, is construction supervisor, Northeast Ohio Regional Sewer District and Brian Negrea, member UCA, is tunnel engineer, McNally Tunneling Co., email scialpi@mcmjac.

TABLE 1

Summary of the geological features and design requirements for the Doan Valley tunnels.

Tunnel	Geology				Design			Excavation method	Lining
	Formation	UCS (psi/ Mpa)	RQD (%)	Abrasivity (CAI)	Tunnel length (LF)	Depth (ft)	Finished diameter (LF)		
WCT	Chagrin/ Cleveland Shale	2,800 - 11,500 / 19-79	50-100	0.3 - 0.7	6,200	27-77	8.5	Fully shielded TBM	Two-pass
MLKCT	Chagrin Shale		56-100		2,970	52-97			
DVT			35-100		9,670	48-115	18		One-pass

The geology

The geologic setting for all three tunnels is primarily the Chagrin Shale bedrock, except for a short reach at the end of the WCT drive in Cleveland Shale. In general, the Chagrin and Cleveland shales rock masses are characterized by weakly bedded plans including clay-filled bedding joints and weathered interbeds, near-vertical joint sets and a tendency for slaking.

A summary of the three main tunnel geological and design features is provided in Table 1.

The process

Due to the typical logistics constraints of an urban jobsite, each TBM tunneling operation was planned and had to be executed in sequence, one at a time. The WCT tunnel started first in January 2018, the DVT tunnel in January 2019 and the MLKCT tunnel in October 2019. With few exceptions (mainly among the laborers), the same workforce has operated both machines and built one tunnel after the others adapting to the different methodologies.

The DVT starter and tail tunnel mining operation between April and August 2018 was arranged on three, eight-hour shifts, working five days a week. The roadheader excavation was performed mainly during the second shift, in an effort to keep the shotcrete supply and application on the day shift.

The WCT/MLKCT and DVT tunnel operations were arranged in two main stages: the TBM initial mining and the TBM full production mining. For the WCT, the first stage was on one eight-hour shift per day. The second was on two eight-hour shifts per day. For the DVT, the first stage was on two eight-hour shifts per day. The second was on three, eight-hour shifts, always working

FIG.2

Panoramic view of the main mining site (Ambler Park) at the time of RCP installation in WCT and TBM mining at DVT.

five days a week. For the MLKCT, both initial mining and full production mining were executed on two, eight-hour shifts.

It must be noted that while TBM operation repeats itself across each shift, and crews have all the same composition, the roadheader operation crew changes during the production cycle based on the sequential task to be performed (excavation and muck removal, scaling, rock-bolting and mesh installation, shotcrete).

Common to all the tunnel headings and tunnel operations performed at Doan Valley is the muck haulage system, which is made up of three stages. First, the muck is placed in muck boxes by bucket-style equipment (roadheader operation) or a conveyor (TBM operation). Once the box is positioned at the bottom of the shaft, it is then hoisted up using a crawler crane and dumped into a temporary muck pile on the surface. There, a front-end loader transfers the muck into dump trucks for transportation off site.

With a low range of rock strength, very low abrasivity (as far as TBM practice) and a tunneling length always less than 3,050 m (10,000 ft), two muck trains were determined to be adequate for each TBM heading to achieve, at reasonable cost, the average advance rate of 1.1 m/h (3.5 ftph) (84 LF/day at DVT; 56 LF/day at WCT and MLKCT).

For all the shaft operations on this project, crawler cranes were utilized primarily for dumping boxes, delivering rib and lagging sets/segments/pipes, delivering supplies/materials, and transferring equipment. The crane also served as a secondary means of emergency egress with a man cage always staged within proximity to the shaft.

The methodology

The roadheader is a highly mobile excavation machine, however it attacks only a portion of the face at any one time and is therefore limited to a fraction of the performance of the TBM. For this reason, its use at the Doan Valley Project had to be minimized to the tunnel length and horseshoe profile exactly needed to allow a smooth assembly and launch of the 6.4-m (21-ft) TBM.

Instead, the shielded TBM mines the full face, providing:

- The maximum possible grade of safety for the workers.
- A much higher grade of automation of the production process (excavation and lining).
- High performances out of mechanization and full-face excavation.
- A finished tunnel, in case of segmental lining (a single-pass tunnel lining).

TABLE 2

Roadheader AQM 150 specifications.

Manufacturer	Antraquip
Cutterhead type	Two transverse ripper drums
Cutter bits	Rotating point attack, tungsten-carbide
Cutterhead power	130 kW (177 hp)
Cutting height / width (max)	4,876 mm (16′) / 5,400 mm (17′-1″)
Undercut (max)	180 mm (7″)
Width of loading apron	2,000 mm (6′-7″)
Machine weight	35 ton (77,000 lbs)
Machine length	12.8 m (42′)

Roadheader specifications and starter tunnel (ST) production cycle. The AQM 150HR roadheader was shipped to site completely assembled, except for the operator roof support and swing extension conveyor assembly on the back side of the machine. The overall mobilization for this machine took four shifts, which is a major advantage of using this equipment on short tunnel drives. When the power supply and the site logistics are setup for it, the roadheader becomes almost a plug-and-play operation. The initial mining stage for this operation is irrelevant as it does not compare to the other methods.

The excavation cycle began with the entire 102 m (335 ft) length of starter tunnel top heading. This was limited by design criteria to maximum of 3 m (10 ft) advance and the roadheader backed away from the face and off to one side of the tunnel, to allow installation of the ground support during the following two shifts (rock bolts, wire mesh and shotcrete).

Once the 102 m (335 ft) of top heading was completed, the roadheader was moved back to the shaft to excavate the additional 3 m (10 ft), down to the DVT invert elevation. From the lowered shaft bottom elevation, the roadheader excavated the 102 m (335 ft) of DVT starter tunnel bench, the 47 m (155 ft) of tail tunnel and the 9 m (30 ft) of MLKJCT starter tunnel, with excavation heading alternation (so as to maximize the machine utilization).

The roadheader daily production chart in Fig. 4 shows the overall production of the entire operation, which includes all three headings. The first portion of the chart, which only represents the DVT starter tunnel top heading, is the only section where the roadheader operated from start to finish without alternating between multiple headings. Therefore, for this paper, this data best compares to the other excavation methodologies.

After completion of the DVT, the cast-in-place final lining will be installed in the DVT starter tunnel. This structure will match the inside diameter of the DVT segmental lining (5.4 m or 18 ft).

FIG.3

Roadheader bench excavation in the DVT starter tunnel.

3.6 m (12 ft) TBM specifications and WCT/MLKCT production cycle. A 3.6 m (12 ft) Robbins main-beam open-gripper TBM was used for the excavation of the WCT and the MLKCT. To date, this TBM has completed more than 49,000 m (160,000 ft) of rock tunnel in both Canada and the United States, including several previous projects for the NEORSD in Cleveland, OH. In 2009, Herrenknecht refurbished this machine and added a floating tail shield for a wider range of applications (e.g. unstable ground) than a traditional open shield gripper TBM.

The muck from the cutterhead is conveyed by the machine and back-up conveyor toward five muck boxes, which are pulled under the conveyor discharge point by a 13.6-t (15-st) diesel locomotive.

Both the WCT and the MLKCT have a two-pass lining system consisting of:

- Tunnel initial support — expanded steel rib and timber lagging to prevent block falls, slabbing and raveling into the tunnel, installed at completion of each 1.5-m (5-ft) mining stroke.
- Final lining — precast reinforced concrete pipe (2.6 m or 8.5 ft ID with 21.6-cm or 8.5-in. wall thickness) designed in three different lengths (1.2, 1.8 and 2.4 m or 4, 6 and 8 ft) to negotiate different tunnel radii. Each pipe section is lowered

FIG.4

Roadheader daily production.

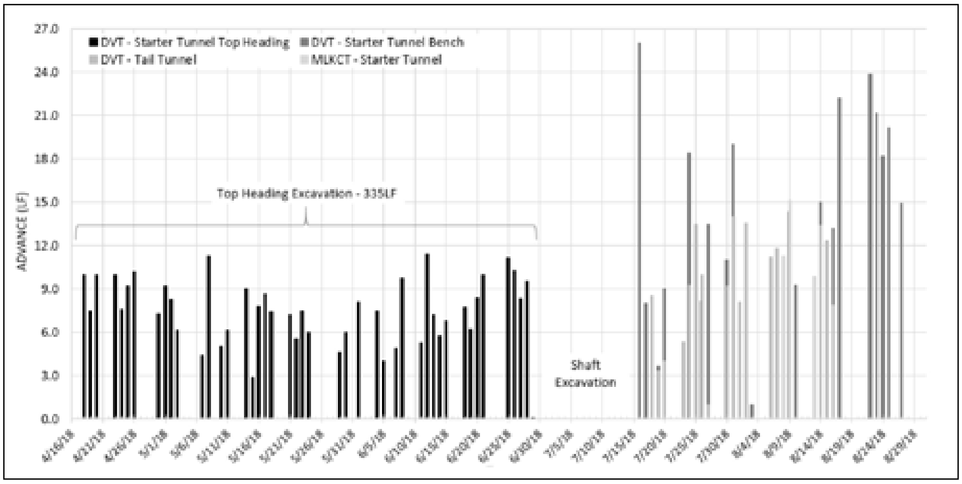


TABLE 3

TBM MB 126-137 specifications.

Manufacturer	**Robbins**
Type	Main beam (open gripper with tail shield)
Year of manufacture	1970
Bore diameter	3.683 m (12'-1")
Cutterhead power	294 kW (400 hp)
Rotational speed	0-6.45 RPM
Cutter type	12-inch discs, single tip
No. of cutters	27
Thrust per cutter	66.7 kN (15,000 lbs)
Total thrust	Nominal: 1,824 kN (410,000 lbs) / Max: 2,247 kN (550,000 lbs)
Stroke length	1,684 mm (5'-6")
Torque	Nominal: 441 kN-m (325,530 lb-ft)
Min. horizontal curve radius	228 m (750 ft)
Machine weight	TBM: 65 ton (143,300 lbs); BU: 17 ton (37,500 lbs)
Machine length	TBM+BU : 63,7 m (209')

in the shaft and then transported into the tunnel using a pipe carrier. Next, the annular gap between the extrados of the pipe and intrados of the rib and lagging initial support is backfilled with cellular grout to provide good lining to rock contact and reduce voids.

6.3 m (21 ft) TBM specifications and DVT production cycle. A 6.3 m (20.75 ft) diameter single-shield TBM was specifically designed and built for the Doan Valley Tunnel.

Based on lessons learned in the past, in similar geologies, the machine design implemented some job specific features:

- Larger loading buckets to minimize cutterhead clogging.
- Stepped design shields to prevent entrapment in softer and potentially unstable shale.
- Active articulation between front and center shields for better control of the cutterhead lookup in softer shale (where the typical machine tendency is to dive).
- Tail shield circumferential joint fully welded to the rear shield (instead of articulated) to strengthen the rear section of the machine and minimize any deformation of the tail can.
- Continuous TBM/back-up conveyor belt to minimize the number of dumping points and reduce the potential for dust.
- Extended erector longitudinal travel to easily reach and expose the tail seal brushes for inspection.
- Extended verification drill and platform longitudinal travel with the ability to operate probing and contact grouting along a five-ring span.
- Lift pedestals welded on each side of front and center shield to jack and swiftly push the whole TBM to the face, in the 102-m (335-ft)-long starter tunnel.

The initial support and final lining for the DVT is a one-pass system consisting of fiber-reinforced precast concrete segments assembled into rings, concurrently with the TBM advance. Each universal design ring is made up of five 25-cm (10-in.)-thick — 1.5-m (5-ft)-long segments plus a key. The annular gap outside of the segmental lining is filled while the segments are leaving the shield with bi-component grout through four injection ports in the tail shield.

The machine was designed for a maximum advance rate of 100 mm/min, and during the entire DVT drive it was consistently operated in the 80-100 mm/min range and in the 5,000-7,000 kN range of thrust force. The total duration of the excavation cycle was typically between 40 and 50 minutes (15-20 minutes for the 1.5-m (5-ft) mining stroke and 25-30 minutes of ring build). The next cycle however could not start until several minutes later, being the muck train

FIG.5

WCT TBM operations.

re-set cycle at the shaft 55 to 65 minutes long (5 to 25 minutes more than the excavation and ring build time).

Only one (gage) cutter was changed during the whole drive. In such a soft rock the challenges were typically represented by the diving tendency of the machine, the over breaks in the crown and the clogging tendency of the loading buckets especially in the presence of ground water at the face (in addition to the water from the lined tunnel, being DVT a 0.17 percent downhill drive).

TABLE 4

TBM S-1112 specifications.

Manufacturer	**Herrenknecht**
Type	Single shield hard rock
Year of manufacture	2018
Bore diameter	6.325 m (20′-9″)
Cutterhead power	1,280 kW (1,740 hp)
Rotational speed	0-8 RPM
Cutter type	17-inch discs
No. of cutters	39
Thrust per Cutter	267 kN (60,024 lbs)
Total Thrust	Nominal: 33,778 kN (7,593,596 lbs) / Max: 42,576 kN (9,571,493 lbs)
Stroke Length	1,684 mm (5′-6″)
Torque	Nominal: 441 kN-m (325,530 lb-ft)
Min. Horizontal Curve Radius	228 m (750 ft)
Machine Weight	TBM: 65 ton (143,300 lbs); BU: 17 ton (37,500 lbs)

Initial mining and learning curve analysis

For the scope of this paper, the initial mining is defined as the period of time and linear footage of tunnel that goes from the day the excavation commenced to the day the whole production system reached its final configuration (in terms of machine fully operational, two production trains able to cycle themselves and crew fully deployed).

If irrelevant for the roadheader drive, this transition between assembly time and full production mining represents a crucial phase for any TBM project. At the initial mining stage, the machine can be tested under load and fine tuned, the crew can finally familiarize themselves with the new equipment and operation, and the whole supply chain gets calibrated to the TBM needs.

Machine mobilization. A substantial difference between the three methodologies is in the mobilization time. The roadheader traditionally requires minimal field assembly effort and can be made ready to mine in very few shifts.

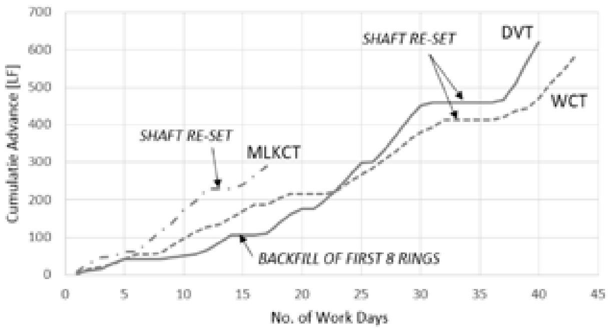
The 3.6-m (12-ft) main beam TBM is essentially made of a front section of the main beam (with cutterhead, main drive, tail shield and gripper carrier) and a rear section of the same beam carrying the operator station, the main electrical cabinets, and the hydraulic power unit. When powered up, this core front section of the machine can be made ready to bore in less than a week. The back-up decks with miscellaneous equipment are then added one at a time and directly towed by the front section of the machine during the initial mining stage.

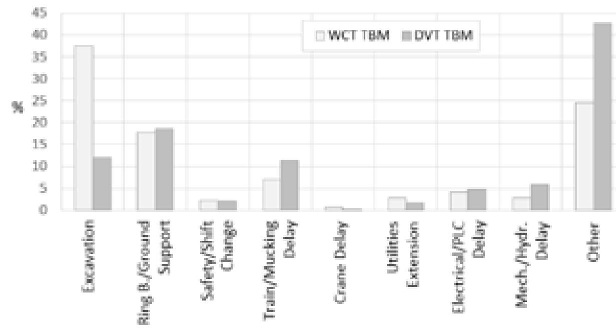
FIG.6

DVT TBM operations.

FIGS. 7 & 8

Cumulative advance and production time breakdown at initial mining.





After the shop tests, the 6.4-m (21-ft) TBM was broken down into 49 major components and six containers of miscellaneous parts, for a total of 55 truckloads. It took two weeks to receive it all and then three months to make it ready to bore (including five weeks of round-the-clock field weld and two eight-hour shifts per day for pre-assembly on the surface, assembly at the bottom of the shaft, skidding to the launch cradle, hydraulic/electric connections and testing).

The machine was launched with six of the eight back-up decks completely assembled in the starter tunnel. With the exception of ventilation and dewatering, every other system was in its final configuration and all temporary set-ups (typical of the launching phase), were kept to a minimum.

In summary, the mobilization time (from receiving the first component to "ready to bore") was:

- Roadheader for ST: 1.5 work days.
- 3.6 m (12 ft) TBM for WCT: 5 work days.
- 6.4 m (21 ft) TBM for DVT: 76 work days.
- 3.6 m (12 ft) TBM for MLKCT: 3.5 work days.

Advance rates and downtimes. The initial mining stage for all three TBM operations started with a single-rail track and a single train arranged in temporary configuration depending on the launch layout. The initial mining duration was different among the three operations based on the launching logistics and jobsite restrictions at each shaft.

Initial mining ended when:

- The switches and double rail tracks were installed (shaft re-set).
- The second production train was put into service.
- The crew was fully trained and all the scheduled production shifts safely deployed.

Below are the initial mining durations and advance rates for each operation:

- WCT — 176 m (580 lft) advance (4.1 m/d (13.5 lfpd) or 0.5 m/h (1.7 lftph) average) in 43 work days (1 x 8 hr shift).
- DVT — 189 m (620 lft) advance (4.7 m/d (15.5 lftpd) or 0.27 m/h (0.9 lftph) average) in 40 work days (2 x 8 hr shifts).
- MLKCT — 88 m (290 lft) advance 5.8 m/d (19.3 lftpd) or 0.37 m/h (1.2 lftph) average) in 15 work days (2 x 8 hr shifts).

As shown in Fig. 7, the MLKCT initial mining required less than half the duration and the length of WCT, which was bored using the same TBM. Both the jobsite parameters and the experience of the crew directly affected this outcome. The WCT was launched from a 23 m (75 ft) long x 4.5 m (15 ft) wide x 9 m (30 ft) deep portal shaft which was supported by a soldier pile and waler frame construction. For this drive, the required initial mining advance was 88 m (290 lft) further than the MLKCT due to the size restriction of this portal shaft. During the MLKCT, the entire 47 m (155 lft) of tail tunnel and 9.1 m (30 lft) of starter tunnel were utilized for the initial mining operation. This was an advantage as the machine did not have to mine as far before the double rail tracks and second production train could be put into service. From a crew standpoint, the key players that were part of the WCT and DVT drives were kept for MLKCT and strategically placed from the beginning on the two shifts. There was an adjustment period for the workforce, from the comforts of the highly automated DVT TBM back to the tight spaces offered by a 3.6-m (12-ft) diameter TBM, with construction material largely handled manually and the increased potential for injuries.

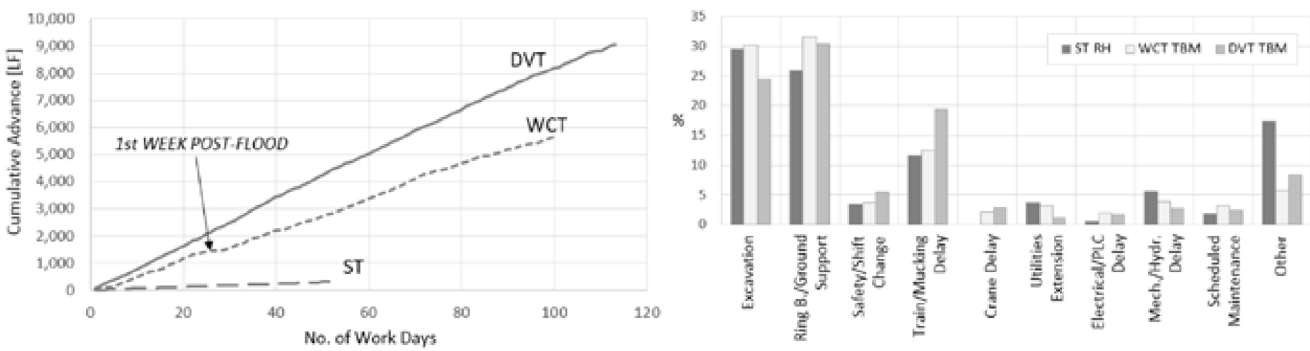
Similarly, during the DVT initial mining (on a single-rail track) only one production train was utilized. After six weeks and 189 m (620 lft) of advance, the switches and double rail tracks were installed, the second production train put into service, and the third eight-hour shift implemented.

A faster advance rate was initially achieved at WCT, even working one shift less than at DVT. In fact, in the first 20 work days at WCT the advance was suspended only for back-up deck installation and ventilation setup. On a larger and more complex machine as DVT the first four weeks have been heavily affected by:

- Blocking and backfill of the first eight rings built above the launch cradle, in the horseshoe section.

FIGS. 9 & 10

Cumulative advance and production time breakdown at full production mining.



- Testing/commissioning of the annular grout system and systematic verification drilling.

This is evidenced in Fig. 8, where delays in the process not specifically related to the respective machines (external delays such as shaft re-set and segmental lining backfill) are captured under "Other."

The same chart also shows a substantial difference between excavation time at WCT and DVT. At the early stages of the initial mining, the main-beam TBM experienced gripping issues in the soft shale that limited the cutterhead thrust to a minimum. As a consequence, the penetration was reduced, and each push extended in time. In addition to this, for the entire time on a single-rail track only two muck boxes could be loaded, exposed and lifted out of the short launching shaft. This resulted in a fragmentation of the 1.5 m (5 ft) mining stroke into two or three sub-strokes per push (about 1 lft advance per each 8 cu yd box) and an overall extension of the excavation time.

None of this was an issue at DVT, where the single shield TBM was thrust forward against a reaction frame, and the length of the starter tunnel (combined to the co-axial tail tunnel) allowed the full muck train (seven boxes) to be utilized from the beginning.

Based on the chart in Fig, 7, 23 work days into the start-up process the DVT daily advance rate overtakes the WCT rate and the gap gets wider after the shaft re-set.

Full production mining analysis

As anticipated, the roadheader operated within the full production mining range from the beginning and for the whole excavation of the starter tunnel top heading. In the case of the TBMs, the production records fall into this range when two essential conditions are met: the operation is run with two production trains and the crew is fully deployed (on 2 x 8 hour shifts in case of WCT; on 3 x 8 hour shifts in case of DVT).

No MLKCT data will be shown in this section, due to the fact the full production mining phase just started at the time this paper was submitted.

Advance rates. In terms of advance rates, all three curves in Fig. 9 demonstrate a very consistent operation throughout the duration. The average advance rate recorded at WCT was 17.7 m/d (58.1 lftpd) or 1.1 m/h (3.6 lftph) (on 2 x 8 hour shifts), with 27.7 m (91.1 lft) mined on the best day and a total of 472 m (1,549 lft) advance in the best month. This was achieved in October 2018 (second month of full production mining after the flood) in the range of 914-1,371 m (3,000-4,500 lft) distance from the shaft. The only deflection in the WCT curve is due to the single shift advance in the week of Aug. 27, 2018, which was the re-start of the operations after the tunnel flood experienced on April 15 of the same year.

The average advance rate recorded at DVT was 24.4 m/d (80.1 lftpd) or 1 m/h (3.3 lftph) (on 3 x 8 hour shifts), with 33.5 m (110.1 lft) mined on the best day and a total of 587 m (1,925.8 lft) advance in the best month. The top production records were all achieved in May 2019 (second month of full production mining) in the range of 914-1,828 m (3,000-6,000 lft) distance from the shaft, similar to what was observed at WCT. It was predicted for both tunnels that the two muck train logistics (with muck boxes dumping time always on the critical path of the production cycle) would have performed at its best in the second half of the WCT drive and in the second third of the DVT drive. That is when the excavation + ring build + train transit time

FIG.11

Average machine utilization and availability at full production mining.

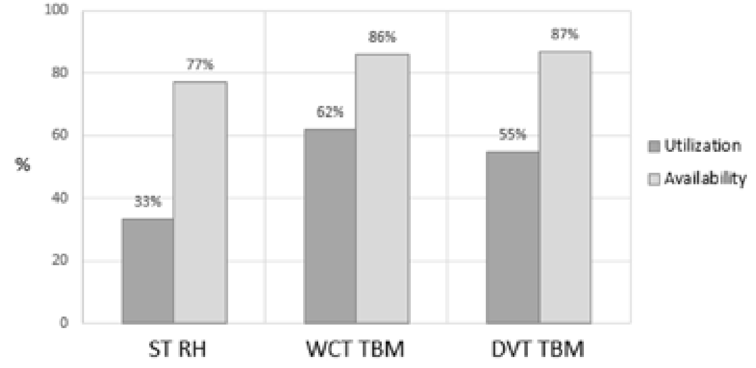
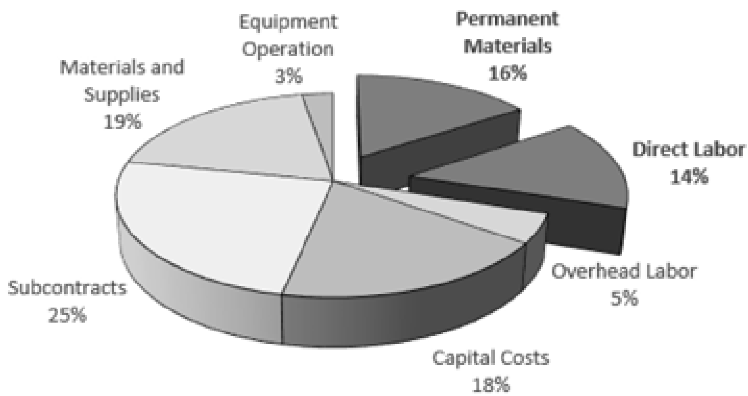


FIG.12

DVT projected cost distribution.



was expected to equalize the time required to dump the muck boxes and re-set each train (40-45 minutes at WCT; 55-65 minutes at DVT).

The average advance rate recorded during the excavation of the starter tunnel top heading was 2.3 m/d (7.48 lftpd) or 0.09 m/h (0.3 lftph) (on 3 x 8 hour shifts), with 3.4 m (11.42 lft) mined on the best day and a total of 43.2 m (141.95 lft) advance in the best month. This was achieved in June 2018 (second month), with best day in the range of 70-75 m (230-245 lft) distance from the shaft.

As largely expected, irrespective of the excavation methodology, the muck removal and the supply chain soon became the main factors driving the pace of the tunneling cycle (Fig. 10). With careful planning and surface/underground crew coordination, some non-boring activities have been worked on simultaneously, so that the actual downtime was less than the sum of the parts. Specific to DVT, ordinary maintenance, survey tasks, utility extension, grout ports cleanup, annular grout verification drills and contact grout would normally be performed as needed during ring build and while waiting for the next muck train. Cutterhead inspection and grout system cleanup are performed during scheduled maintenance time (typically once a week).

The large amount of time under "other" for the roadheader process is related to the frequent changes in operation within the production cycle (from mining to bolting, from bolting to shotcreting, from shotcreting back to mining).

Machine availability and utilization. Maximizing the overall advance rate of a tunneling system is dependent not only on the excavation speed that can be achieved, but also on minimizing the time that the system is not operating (downtime). The efficiency of the system is usually measured by the "utilization," defined as the percentage of the total shift working time or total production cycle in which the productive capacity of the machine is used. Nonworking shifts, weekend days and holidays are not included. A related term is "availability," to express the percentage of time that the machine is available for use, divided by the maximum amount of time it would be available if there were no downtimes for repair or unplanned maintenance. The availability has a direct bearing on the utilization.

At Doan Valley, 62 percent utilization was achieved on the 3.6-m (12-ft) TBM (excavation and ring build) during the WCT full production mining. This is about 7 percent lower on the 6.4-m (21-ft) TBM, mainly because at higher penetration rates the utilization tends to decrease (as excavation time is reduced). The low 33 percent for the roadheader, reflects the fact that the machine was utilized for one-third of the whole production cycle (excavation only), while the remaining time was spent operating different equipment for installation of ground supports. The high availability (always more than 75 percent, up to 87 percent on the 3.6-m (21-ft) TBM) reflects the effectiveness of the maintenance work mostly performed during the routine downtimes, built into each production cycle (rock support installation in the case of the roadheader or waiting for the next production train in the case of the TBMs).

It is interesting to note that within the same geology, operating process and crew, there is almost no difference in terms of availability (also read as reliability) between the brand new TBM (DVT) and the repeatedly rebuilt TBM (WCT).

TABLE 5

Material cost summary.

Permanent material cost per linear foot	DVT	WCT	Starter tunnel
Fiber-reinforced segmental lining + annular grout	100		
Rib and lagging		11	
RCP + cellular grout		37	
Rockbolts + wire mesh + shotcrete			11
Cast-in-place concrete			77
Total	100	48	88

Material and labor cost analysis

This review is confined to the material placed and left in the tunnel (ground support and/or final lining) and the direct labor hours involved with each construction process. From the estimating stage, the labor cost and the permanent material combined represented the first and biggest contribution to the construction of the three tunnels and was therefore a major target for

TABLE 6

Labor cost summary.

	Initial mining	Full production mining	Overall mining	Mining + final lining
ST	-	60	60	100
WCT	14	8	9	12
DVT	30	11	13	13
MLKCT	7	-	-	-

reduction with improved performances.

In general, the cost of the materials left in the tunnel tends to be higher with the size of the tunnel. Considering that only the DVT was a single-pass tunnel, Table 5 provides an actual measure of how the WCT and the ST compare to the permanent material cost in the main tunnel (in absolute terms, assuming DVT=100 per linear foot).

The main benefits of a single-pass approach are in terms of earlier availability of the tunnel and overall reduction in labor cost per linear foot of tunnel excavated. Table 6 provides an actual measure of how the WCT, DVT and MLKCT compare to the labor cost in the Starter Tunnel (in absolute terms, assuming ST=100 per linear foot).

The man hours per foot spent at MLKCT initial mining are half of what was invested at the same stage of the WCT drive. This is in line with what was already pointed out analyzing average advance rates, distances, and durations of the respective initial mining stages. It is remarkable but not unexpected the amount of hours that go into moving a larger machine forward up to the point the second production train can be implemented, especially when those (DVT) hours are more than double if compared to WCT, more than four times if compared to MLKCT.

At the full production mining stage, the low efficiency and high labor cost of the roadheader operation are the reasons why the length of the service tunnels must always be minimized, with careful reflection. A starter tunnel only five feet shorter would have meant no room for back-up deck no.6, and a whole set of labor-intensive temporary arrangements that would have heavily impacted the TBM launch.

The disproportion between the TBM tunnels and Roadheader tunnel becomes even more striking if considering the man-hours required to bring the 23' wide by 23' high horse shoe section of the starter tunnel down to the 18' dia. of the DVT final lining. At the same time, after the direct labor cost for the second pass (pipe installation and cellular grout backfill) is factored in, the delta between WCT and DVT becomes minimal.

Conclusions

At Doan Valley, due to the relatively short length and duration of each tunnel drive, the start-up phase of each tunneling operation (initial mining) had to be reduced to a minimum, so as to achieve the scheduled advance rates as quickly as possible. At this stage, in terms of hourly footage, the 3.6-m (12-ft)-diameter main-beam TBM performed up to two times better than the 6.4-m (21-ft)-diameter single-shield TBM, and in terms of labor cost up to four times better than the 6.4-m (21-ft) TBM.

Following the initial mining, steady system performances had to be maintained throughout the entire "full production mining" phase, turning the downtimes built into each cycle (such as the muck boxes handling at the shaft) into opportunities for concurrent non-mining tasks. In this scenario, the machine utilization achieved by both TBMs was twice the one recorded for the roadheader with hourly advance rates 10 times greater than for the roadheader.

In terms of material cost per linear foot of finished tunnel, the one-pass tunnel lining solution result was comparable to the cast-in-place option but two times more expensive than the two-pass. In terms of labor cost per linear foot for the finished product, the starter tunnel turned out to be almost 10 times more expensive than both TBM tunnels. This is the reason why every effort was made to optimize the cross section and length of the service tunnels.

Across the whole process, a key factor was the detailed planning and engagement of the key field players from the early stages. Then, the same crews were deliberately kept together for more than two years on three separate, but in many ways comparable, tunneling operations, to minimize the learning curves.

As a result, what was accomplished at each drive was not record-breaking production, but a performance consistency in the scheduled distance/time and within the budgeted costs. ■

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Design-build procurement of the Hampton Roads Bridge-Tunnel Expansion

The $3.86 billion Hampton Roads Bridge-Tunnel Expansion (HRBT) project in southeastern Virginia developed rapidly from concept selection in December 2016 to contract award in April 2019. During this time, the Virginia Department of Transportation (VDOT) evaluated whether to structure the procurement as a privately financed P3 or publicly financed design-build; engaged regional stakeholders and the tunneling community to choose between immersed-tube and bored-tunnel construction alternatives; identified and retired cost-driving risks during procurement; and continuously refined the project scope. This ultimately entailed a 2.4-km (1.5-mile) four-lane tunnel crossing, 4 km (2.5 miles) of marine bridges and 8 km (5 miles) of highway widening.

Hampton Roads is the second-largest metropolitan area in Virginia, with a regional population of around 1.7 million people across 15 localities. The region takes its name from the maritime roadstead at the confluence of the Elizabeth, Nansemond and James Rivers as they enter the Chesapeake Bay and ultimately the Atlantic Ocean.

This maritime influence is significant for Hampton Roads' extensive tunneling history, since the region is home to numerous military installations including the Naval Station Norfolk, the largest naval base in the world. Due to U.S. Navy requirements, no bridges are permitted above the major navigable waterways leading to the Atlantic Ocean, resulting in the large number of marine tunnels in this area.

Due to the region's soft soils, though, only immersed-tube tunneling was feasible in this geology for many years. Relative to the widespread use of bored tunnels, the immersed-tube construction method is comparatively newer and less frequently employed. The *ITA Catalogue of Immersed Transportation Tunnels* (Rasmussen and Grantz 1997) records the first such tunnel as having been built in Detroit, MI in 1910. As of 1950, there were only 10 examples in existence worldwide, seven of which were in the United States.

Even so, Hampton Roads was an early adopter of immersed-tube tunneling due to the constraints noted above and nine subaqueous tunnels comprising 10 two-lane tubes have been constructed there since 1952 (Table 1). By 1957, when the Hampton Roads Bridge-Tunnel (HRBT) opened, it was only the 15th immersed transportation tunnel in the world.

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Unlike the 1952 Downtown Tunnel, which crossed the Elizabeth River directly shore-to-shore, the 1957 Hampton Roads tunnel could not span the entire 5.6 km (3.5-mile) mouth of the Virginia harbor. Tunnel-ventilation technology at the time was not sufficient to support this length for a highway tunnel without intermediate shafts. Since the Navy's bridge-building restrictions applied only to the navigation channel, engineers developed the idea to construct artificial islands bordering the channel, immerse the tunnel between these islands and then connect this roadway to shore via low-level trestle bridges over shallower, nonnavigable water.

Given the width of the navigation channel, though, the necessary length of the resulting tunnel was still extraordinarily long for its day. When it opened in 1957, the HRBT was the longest subaqueous tunnel in the world, with an immersed length of 2,091 m (6,859 ft) and a total portal-to-portal length of 2,280 m (7,479 ft), including the cut-and-cover segments at each end of the tunnel.

The HRBT's 1957 opening also marked the first time worldwide that a marine tunnel had been constructed between artificial islands (Fig. 1). This concept was replicated successfully throughout coastal Virginia, with the 1964 Chesapeake Bay Tunnels, the 1976 Hampton Roads Tunnel (Fig. 2) and a 1992 Monitor-Merrimac Tunnel also incorporating manmade islands connected to land via trestle bridges. Southeastern Virginia remains one of the world's densest concentrations of immersed-tube tunnels, particularly those featuring artificial islands.

The new Hampton Roads Bridge-Tunnel

Contract scoping. The twin Hampton Roads tunnels had become heavily congested by the early 2000s, with traffic on the four-lane crossing averaging nearly 90,000 vehicles per day and exceeding 100,000 daily vehicles during peak summer travel. When Virginia's Commonwealth Transportation Board recommended an HRBT expansion in December 2016, VDOT moved forward with shaping the contract scope and procurement approach for this project.

The project's concept design included not only a 2.4-km (1.5-mile) four-lane tunnel crossing, island expansions and 4 km (2.5 miles) of marine bridges, but also 8 km (5 miles) of conventional landside highway widening. To confirm market interest in this scope, VDOT conducted an industry sounding in April 2017 with a formal request for information and pre-procurement one-on-one meetings with interested contractors and developers.

With preliminary studies having estimated the cost of this scope at more than $3 billion, feedback from the

TABLE 1

Immersed-tube tunnels in Hampton Roads.

Ref. No.	Tunnel	Immersed Length	# of Lanes	Year completed
12	Elizabeth River No. 1 (now Downtown Tunnel, westbound)	638 m	2	1952
15	Hampton Roads No. 1 (now Hampton Roads Bridge-Tunnel, westbound)	2,091 m	2	1957
20	Elizabeth River No. 2 (now Midtown Tunnel, eastbound)	1,010 m	2	1962
21	Chesapeake Bay (Thimble Shoal Channel Tunnel)	1,750 m	2	1964
21	Chesapeake Bay (Chesapeake Channel Tunnel)	1,661 m	2	1964
52	Hampton Roads No. 2 (now Hampton Roads Bridge-Tunnel, eastbound)	2,229 m	2	1976
73	Second Downtown (now Downtown Tunnel, eastbound)	765 m	2	1987
81	Monitor-Merrimac (northbound and southbound)	1,425 m	4	1992
–	Second Midtown (now Midtown Tunnel, westbound)	1,150 m	2	2016
Source: Rasmussen and Grantz 1997				

industry sounding indicated that certain bidders would be more likely to pursue the work if it were segmented into smaller contracts. VDOT considered this input but ultimately determined to procure this scope as a single contract, due to the complexities of coordinating interfaces between multiple contracts while safely maintaining high volumes of live interstate traffic.

Given the size and complexity of this scope, coupled

FIG. 1

HRBT under construction in the 1950s, viewed from South Island to North Island. Source: Virginia Department of Transportation.

FIG. 2

HRBT in 2018, viewed from South Island to North Island (1957 westbound tunnel at right; 1976 eastbound tunnel at left). Source: Virginia Department of Transportation.

with the agency's prior experience in alternative delivery methods, VDOT determined from the outset not to use design-bid-build procurement. As such, the agency advanced the concept design only to the level necessary for identifying preliminary right-of-way impacts, conducting the required design public hearings and developing cost estimates to help ensure the scope remained within budget limits.

Procurement method. The April 2017 industry sounding also provided valuable input on the question of whether to structure the procurement as a privately financed P3 or a publicly financed design-build project. Both were conceptually feasible, with three teams having submitted unsolicited public-private partnership (P3) proposals for an HRBT expansion in 2010 and 2011, and with the parallel Midtown Tunnel having been procured as a P3 in 2011.

Since then, though, Hampton Roads had developed its own transportation funding stream via a regional tax dedicated to major congestion-relief projects. The Hampton Roads Transportation Accountability Commission, which was founded in 2014 to administer revenues from an increased 0.7 percent sales tax and 2.1 percent fuel tax, had sufficient financial capacity to fund 95 percent of HRBT project costs. In addition, state policy determined that only the new HRBT capacity could be tolled, with the existing four-lane capacity remaining free of charge for travelers.

Based on these considerations, industry participants felt the business case for a publicly financed design-build approach was stronger than for a privately financed P3. VDOT incorporated this feedback and issued a design-build request for qualifications in December 2017, shortlisted three teams in April 2018 and issued a request for proposals (RFP) in May 2018.

Risk management during procurement

Although VDOT encouraged proposers to develop innovative solutions within the design-build context, the agency recognized widely differing interpretations of certain performance-based specifications could introduce unintended risks — either for the proposer, the state or the public — into the project. In these areas, VDOT set prescriptive specifications instead of the performance-based specifications that are traditionally used in design-build contracts.

The goal was to help ensure proposers competed on their merits, rather than on differences in risk appetite. Although a higher-risk proposal could potentially offer a lower bid price, VDOT preferred not to incentivize this strategy nor to encourage a design that reduced construction costs at the expense of greater operations and maintenance effort in the future. To address this, VDOT also structured the technical portion of the best-value selection criteria, which assigned 60 percent of the evaluation score for price and 40 percent for technical merit, to reward lower-risk approaches.

In cases where a prescriptive specification interfered with an innovative approach that a proposer felt had particular merit, the proposer could submit the idea as an alternative technical concept (ATC) and explain its risks and benefits in confidential one-on-one meetings. The ATC process allowed VDOT to evaluate the risk profile of these

FIG. 3

Immersion of first segment of 1976 HRBT tube within footprint of South Island. Source: Virginia Department of Transportation.

concepts and make a determination whether to allow, or conditionally allow, each concept.

Immersed tube or bored tunnel? One example of the tension between prescriptive and performance-based specifications involved the selection of the tunnel-construction method for the new HRBT. Although all existing tunnels in coastal Virginia are immersed tubes (e.g., Fig. 3), the Parallel Thimble Shoal Tunnel procurement had received three TBM tunneling proposals in early 2016, indicating soft-ground TBM technology had advanced sufficiently to enable bored tunneling in this region.

Although VDOT had initially assumed the new HRBT would be an immersed-tube tunnel, the agency decided — based on this new information — to give proposers the option to select the method they believed was best suited to project conditions and proposers' individual strengths. Accordingly, VDOT's concept design was silent regarding tunneling approach, and the request for proposal contained performance-based specifications that accommodated both immersed-tube and bored tunneling methods. Proposers were instructed to evaluate the available information and declare their chosen method in July 2018.

To aid in this decision, VDOT provided extensive geotechnical data, including 1953 and 1969 boring logs from the existing tunnels, and the spring 2018 ground investigations at the HRBT islands. Proposers also received input from regional maritime stakeholders, who noted the 8,800 vessel movements per year across the HRBT and expressed concern regarding the potential mutual risks to shipping and to immersed-tube tunneling operations sharing an active navigation channel.

Based on this information, one of the three shortlisted teams, which had submitted qualifications only for immersed-tube tunneling, declined to continue with the procurement. Both remaining proposers declared their intention to advance with a bored-tunneling approach, and VDOT subsequently amended the RFP to prescribe this construction method.

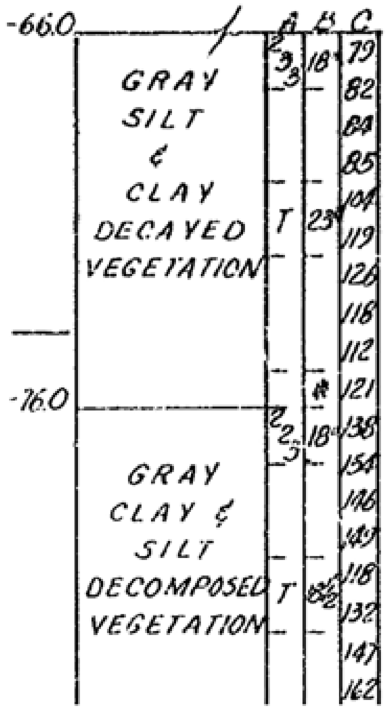
Soft soils at South Island. The soft soils at HRBT's South Island presented another example in which VDOT recognized that differing interpretations of performance-based specifications could introduce unintended risks. Despite the proximity of the North and South Islands, geotechnical conditions vary greatly between them, as noted by Kuesel et al. (1973): "The North Island is founded on sands and silty sands and presents no substantial settlement or stability problems. At the South Island, however, about 80 feet of normally consolidated clay overlies sandy soils."

The challenging soil conditions at the South Island had been known since the 1820s, when the U.S. Army's attempt to construct heavy masonry fortifications nearby was hindered by unexpected cracking and settlement. From geotechnical borings, engineers identified thick layers of soft clay, silt and organic materials (Fig. 4), which were excavated by dredging prior to construction of the 1957 tunnel.

For the 1976 tunnel, though, a similar dredging program would have destabilized the 1957 tunnel unless the new tubes were built prohibitively far away. Instead, the design prescribed sand drains and 8 m (26 ft) of surcharge above the island's finished elevation. Fifteen months after the surcharge reached its full height, Kuesel et al. (1973) reported a maximum settlement of 4 m (13 ft) under the highest fill near the north end of the island, "where the clays are thickest and more plastic than average." The South

FIG. 4

Excerpt from 1969 boring log B-103, near center of HRBT South Island. Source: Virginia Department of Transportation.



Island footprint ultimately measured 0.1 sq km (24 acres), significantly larger than the North Island, to accommodate this temporary surcharge mound.

Given the ample unoccupied space on the South Island, the proposers for the HRBT Expansion found it attractive to locate the TBM launch shaft there. Engineering judgment differed, though, on appropriate solutions for maintaining the tunnel's vertical alignment along the 5 percent grade as the TBM's heavy cutterhead — approximately 14 m (46 ft) in diameter — passed through these very soft layers. Because ground improvement along this portion of the alignment would be a significant cost item, VDOT recognized the proposers could be tempted to gamble on the risk in this location. Hence, the agency mandated a conservative program of ground improvement in the RFP technical requirements: "Wherever any part of the tunnel below the springline would lie within the soft clays and organics (layers Qf and Qo as defined and baselined in the GBR), the Design-Builder shall provide ground improvement to these in-situ soils in advance of tunneling.

"This ground improvement shall extend from the tunnel springline to a minimum depth of one half of the tunnel outside diameter below the tunnel invert, or 2 feet below the base of the soft clay and organics layers, whichever is less. In addition, the ground improvement shall be performed over the width of the TBM plus a minimum of 5 feet on either side."

Although this approach was conservative, it helped lessen the bidding pressure for proposers to develop a risky engineering solution in an attempt to gain a pricing advantage. VDOT advised the teams that the selected proposer would be welcome to submit a value-engineering proposal after award, informed by additional geotechnical investigations along its specific alignment, to reduce the contract's prescriptive ground-improvement requirements.

Tunnel diameter. The question of TBM diameter illustrated another example where VDOT intervened to address unintended risks arising from different interpretations of the specifications. Initially, the RFP requirements for tunnel dimensions were performance-based, allowing proposers to set their own tunnel diameter as long as it accommodated given vehicle-clearance envelopes plus requirements for ventilation, egress, utilities, finishes and other spaceproofing considerations.

From the one-on-one meetings and written questions submitted during procurement, it became clear the RFP's original provisions were incentivizing proposers to reduce their bid prices by minimizing the tunnel diameter to the smallest possible dimensions. This, however, was not VDOT's intent: a smaller diameter would subtly, but inevitably, complicate operations and maintenance (O&M) tasks throughout the structure's 100-year design life. Even though the individual requirements were accurate per se, the sum of these performance-based specifications did not fully reflect the agency's needs.

In response, VDOT amended the RFP to specify a minimum interior tunnel diameter of 12.6 m (41.5 ft), from concrete liner to concrete liner, in order to eliminate this dimension as a point of competition between the teams. This aligned with other prescriptive O&M guidance already in the RFP: although locating a jet fan directly above the roadway centerline could be efficient from a spaceproofing standpoint, for instance, this was not permitted because all maintenance had to be possible from within a single-lane closure, and servicing a fan directly above the centerline would require closing both lanes of tunnel traffic for safety reasons.

Conclusion

Following award of the HRBT Expansion contract in April 2019, the project team looks forward to continued progress in delivering the next crossing of the Hampton Roads. Throughout this effort, the inputs from past and current industry partners and stakeholders have been invaluable in beneficially shaping the project's procurement structure, design scope, construction method, technical requirements and risk profile. All of these influences have contributed to make this a better project and are gratefully acknowledged. ■

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Part II of webinar on "Underground Construction During the COVID Age" expands on measures taken during the pandemic

As a follow-up webinar to the first installment of this series, the Underground Construction Association (UCA), a Division of SME, held a second webinar titled "Underground Construction During the COVID Age, Part II" on July 1. Three major U.S. tunneling project managers and a professor from the Colorado School of Mines shared their stories as they continue adapting to the challenges raised by COVID-19.

The webinar was moderated by Erika Moonin, president of Moonin Associates, and Robert Goodfellow, president of Aldea Services Inc. The three speakers included Robert Goodfellow, Greg Colzani of Jacobs, John Bednarski of the Metropolitan Water District of Southern California and Mike Mooney of the Colorado School of Mines (CSM).

Jacobs' 3RPORT Tunnel Project in Ft. Wayne, IN.

Goodfellow, who is president of Aldea Services, a small consulting firm of about 35 staff based in Maryland, presented on the topic of design teams — working in the office and at home. After having all staff working remotely the past several months and beginning to transition back to the office, he said they treated it like any situation they'd come up against in various areas of their work, be it construction or otherwise. He told his staff, "If you're not comfortable, don't do it. We'll find alternate ways of dealing with the issue."

As he's had some staff return to the office, Goodfellow explained that people's personal circumstances and different situations are a big factor in deciding whether to return to the office and the terms of exactly what it will look like. He added, "We have about 30 percent who are very keen to get back to the office, particularly those with young children at home."

Goodfellow also explained how they've focused on a mantra of awareness versus paranoia. And different from the usual approach of wearing personal protective equipment (PPE) for one's own safety, the mindset needs to be shifted to mask usage as a means of protecting others.

Touching on the topic of teams, Goodfellow discussed how managers at Aldea have been forced, out of necessity and the good of morale, to improve their communication to a distributed team that's spread out and working remotely.

Looking ahead, Goodfellow said he doesn't think business travel will ever be the same now that video conferencing has been proven as an effective substitute, at least for smaller and less significant meetings, although he clarified that site visits and certain in-person meetings will always be important and will return in the future when travel restrictions associated with the pandemic are lifted.

Next up, Colzani, global practices leader with Jacobs, shared the corporate perspective of how Jacobs has handled the challenges associated with COVID-19. With more than 55,000 employees, Colzani said the benefits of having a larger infrastructure and being able to steer staff to one centralized website for pandemic-related information streamlines communication and connectivity.

Jacobs' chief executive officer, Steven Demetriou, holds weekly town hall meetings, and the human resources staff has organized virtual coffee breaks with smaller groups to provide the connection people miss when they're not in an office setting. Longer term, Colzani added that Jacobs is looking at a potential reduction in hard office space as the shift to remote work

by Margo Ellis
Associate Editor

has been accelerated and proven successful these past few months.

In fact, Jacobs is currently using COVID-19 as a BETA test for many of the tools and processes that will be required for the company to meet its goal of becoming a NetZero Corporation. As part of that, Jacobs has reduced travel (pre-pandemic), increased work schedule flexibility (less commuting) and diversified work opportunities through work-share programs, professional development and increased connectivity.

A local domestic inspector fills in overseas for the Metropolitan Water District of Southern California.

In terms of the construction management side of essential projects, Colzani said the decision has been generally left up to the contractor to determine if the project meets the definition of essential — as determined by governors' shutdown orders — and the states' policies vary.

Two of Jacobs' current projects discussed were the 3PORT Project in Fort Wayne, IN and the Ship Canal Water Quality Project in Seattle, WA. Both considered essential work projects, steps were taken to ensure worker safety and lessened exposure (e.g., holding trainings outside, reduced mantrip capacities, no sharing of tools and required quarantining of anyone thought to be possibly exposed to the virus). For future project considerations, Colzani said some issues will likely be defining and application of force majeure status, insurance provisions (may exclude pandemics in the future), remote work provisions and revising health and safety requirement for pandemic planning.

The third presenter in the webinar, Bednarski, chief engineer at the Metropolitan Water District of Southern California, spoke about managing a staff of more than 350. As the nation's largest wholesaler of water to some 19 million people, Bednarski detailed how the district has increased social distancing by implementing micro teams of three to four people who work only with each other and avoid cross-contamination risks.

With 24 active contracts paused back in March, all except one have been brought back online. Bednarski described other steps that have been taken in preventing spread of the virus, including continued teleworking for those can, virtual job walks and electronic bid submission. The water district has also conducted ongoing temperature checks, although he questioned its ultimate effectiveness. And, he reiterated that PPE is of course required.

Another method the water district has successfully employed is online remote video inspections, where a local domestic inspector is hired and he or she goes out to the shop floor and conducts the close-up inspection of many pieces of the equipment — the results of which are relayed via video back to Metro's staff in Southern California.

The fourth and final speaker was Mooney, professor of civil engineering at the Colorado School of Mines in Golden, CO. With a perspective from the academia side of handling the pandemic's fallout, he discussed the challenges associated with hands-on labs, administering exams without sacrificing academic integrity and canceled field trips.

Mooney said recorded lectures were and will continue to be required. A downfall of our now ubiquitous video-conferencing world, he explained, is that there is noticeably less interaction and dynamic exchange among students. Somewhat unexpectedly, however, he reported that online office hours are up considerably compared to typical in-person office-hours visits.

For international students, their challenges are two-fold as travel is very limited, if not impossible, and they also face visa issues with almost all U.S. embassies closed. Consequently, of the roughly 50 percent who returned home in the spring, almost none of those students is expected to return this fall.

With plans in place for a hybrid model this fall, all classes will have remote delivery for those who don't feel safe. Mooney talked about the unfortunate impacts to state universities that will likely result in hiring freezes, possible salary reductions and furloughs. But a bright spot he ended on is how CSM is has moved to create and develop an online graduate certificate program in underground construction and tunneling engineering. With three eight-week asynchronous courses offered, it will launch in January 2021 — the only program of its kind in North America.

A recording of this free webinar is available on the UCA of SME site at https://bit.ly/33MRfBY. ■

New directors join the UCA Executive Committee

Grover Vargas (supplier representative), Sarah Wilson (engineer representative) and Shane Yanagisawa (contractor representative) were elected to serve on the the UCA Executive Committee during the North American Tunneling Conference (NAT). Erica Moonin (owner representative) was re-elected to a second term.

The four directors will serve until June 2024.

GROVER VARGAS has been working in the tunneling industry since 1997. He is currently business development manager for SIKA-STM a business unit focused on shotcrete, tunneling and mining.

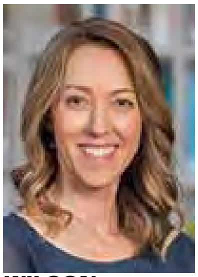
VARGAS

Vargas earned a bachelor of science degree in civil engineering from the Universidad Mayor de San Simon in Bolivia in 1989 and a master's degree in business from the Florida International University in 2003. He began his career with an engineering firm, and during his seven years with the firm, he gained experience in various civil engineering projects. He later worked in the construction chemicals industry with a focus on shotcrete for tunneling and fiber reinforcement for underground construction and pavements.

For 20 years, Vargas worked for Propex/Fibermesh, a global manufacturer of fibers for shotcrete/concrete, where he was regional manager for Latin America. He marketed the benefits of macro synthetic fiber technology in mining and in tunneling.

In addition to being a member of the UCA Division of SME, Vargas is a member of the American Society of Civil Engineers, the American Concrete Institute and the American Shotcrete Association.

SARAH H. WILSON, P.E., CCM, is a principal and vice president with McMillen Jacobs Associates in San Francisco, CA, where she has worked in tunnel design and construction management for more than 20 years.



WILSON

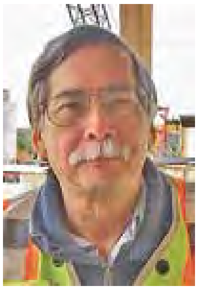
She currently leads the Construction Management Practice for the company and serves as project lead for a pedestrian bridge the firm is undertaking in partnership with Traylor Bros. and Bridges to Prosperity in Uganda.

Wilson has served on the McMillen Jacobs board of directors for five years and is currently the chair. She served six years on the board of the American Rock Mechanics Association and two years as its president.

Wilson received her B.S. in civil engineering from Drexel University and her M.S. in geotechnical engineering from the University of California Berkeley. She was an early supporter and participant in the UCA of SME's Women in Tunneling group and also participates in the McMillen Jacobs professional women's group, WISE. She has authored professional papers and articles on geotechnical and construction management topics, and she edited the second edition of *Recommended Contract Practices for Underground Construction*, published by SME in 2019.

Wilson has produced and managed design for design-build projects such as the Upper Diamond Fork project for Obayashi, Tren Urbano for Kiewit/Kenny/Zachary, and the Blue Ridge Dam for Atkinson. She has also worked on design-bid-build projects such as the MetroWest Water Supply Tunnel for MWRA, the Lenihan Dam Outlet Modifications Project for the Santa Clara Valley Water District and the Millennium Line Broadway Extension for TransLink in Vancouver, BC, Canada.

SHANE YANAGISAWA, P.E. is the project director, Northeast Boundary Tunnel, for Lane Construction Corp. He has 33 years of experience working on major tunnel projects for contractors. He graduated from Rice University in 1979 with a B.S. in civil engineering then joined a structural consulting engineering firm in Houston, TX. He started out as a junior estimator and moved up through the ranks as a cost/schedule engineer, project engineer and project manager.



YANAGISAWA

After obtaining a professional engineer's license in Texas, he earned a master's of engineering degree in construction management in 1986 from the University of Texas at Austin. He began working in the tunneling business in 1988 and has continued to work for tunnel contractors as an engineer or manager. His tunneling experience includes hard rock, earth-pressure-balance and slurry tunnel boring machines, and he has also done conventional drill and blast, shaft sinking and raise boring.

Yanagisawa has written for numerous publications on the practical aspects of tunnel construction. He was the primary author of the chapter on tunnel concrete in *Concrete for Underground Structures* edited by Robert Goodfellow. He has also written on the subjects of tunnel ventilation and conveyor belts. During the last NAT in Washington D.C., he presented at the seminar on tunnel linings and hosted a tour of the factory that was making segments for the Northeast Boundary Tunnel. He

(Continued on page 54)

Center for Underground at CSM designs rapid-tunneling technology

The Center for Underground at Colorado School of Mines (CSM) has received a major contract from the U.S. Defense Advanced Research Projects Agency to design and demonstrate rapid tunneling technology.

According to Mike Mooney, Grewcock Distinguished Chair of Underground Construction and Tunneling and the project's director and lead investigator, "This project should dramatically improve tunneling efficiency. Our approach blends horizontal directional drilling's operational framework and oil and gas directional drilling's proven metric-exceeding speed and distance performance with additional advances in excavation mechanics, tunnel installation, ground imaging and artificial intelligence. This unique project provides an opportunity for step-change advances in tunneling technology that can improve tunnel construction for water, wastewater, transportation, and utilities."

Alfred Eustes, associate professor of petroleum engineering, said, "Our proposed advances aim to drive down the cost of tunneling and dramatically increase the speed of tunneling over current practice. The project is highly interdisciplinary, blending the civil tunneling and horizontal directional drilling expertise at Mines with petroleum drilling engineering, chemical engineering, mechanical engineering and geophysics expertise."

The Center for Underground has brought in full-time engineering professionals with expertise in sensing, artificial intelligence, mechanical systems, smart fluids and instrumentation to work closely with Mines faculty experts. "We are organized as a university-industry melting pot of different disciplines, skill sets and perspectives, with innovative ideas flying all over the place," noted Joe Samaniuk, assistant professor of chemical engineering. Mines will also bring in partners in field testing.

The research team plans a field site demonstration targeting sustained tunneling advance rates of 366 m/hr (1,200 ft/hr) next year. The project will be described during the Tunneling Fundamentals, Applications and Innovations industry short course to be held at Mines Oct. 19-22, 2020. More information can be found at underground.mines.edu. ■

Herrenknecht promotes engineering careers

The Max Planck High School in Lahr, Germany hosted its 10th Engineer's Day in February 2020. The half-day event gives pupils first-hand insight into and information about careers in engineering. The opening presentation was given by Artur Miller, project engineer at Herrenknecht AG. The aim of Engineer's Day is to motivate young people to embark on this career path. The cooperation between Herrenknecht AG and the high school in the education and the promotion of young talent in the areas of science and technology has a long tradition. The company, located in neighboring Schwanau, has been a partner and supporter of the event from the beginning.

"I attended Engineer's Day myself eight years ago when I was a pupil," recalls Miller. "The good training tips and insights from back then were a good starting point for me to find my way to an engineering career." He spoke to about 100 attentive pupils in the school's auditorium, sharing experiences from his training, on international assignments in the United Arab Emirates, Italy and China as well as at the group headquarters in Schwanau. "I am just as fascinated by the big Herrenknecht machines as by the infrastructure projects we travel all around the whole world for."

In addition to Herrenknecht AG, the Offenburg University of Applied Sciences, the Karlsruhe Institute of Technology, Daimler Sindelfingen, Schneider Electric GmbH and Schaeffler Technologies AG & Co. KG took part in the 2020 Engineer's day. After school principal Christoph Bohn welcomed the students and the opening presentation by Artur Miller, the pupils engaged in small groups with the speakers for short presentations. ■

Artur Miller encourages students at Max Planck High School to consider a career in engineering.

HARVEY W. PARKER

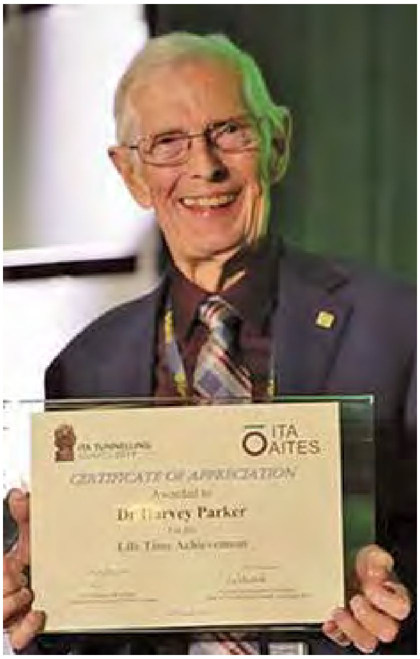
Harvey W. Parker died May 5, 2020 after a two-year battle with cancer. At the time of his death, he was president of Harvey W. Parker & Associates in Bellevue, WA.

Harvey W. Parker received his B.S. in civil engineering from Auburn University in 1957, a master's degree from Harvard University in 1967 and his Ph.D. in civil engineering, with a minor in geology, from the University of Illinois in 1976. He held adjunct or visiting teaching positions at the University of Illinois and Columbia University and was the author or coauthor of more than 60 publications.

Parker's career extended over a period of 50 years, during which he made significant contributions to signature tunneling projects through leadership and technical expertise. Specific examples include the Alaskan Way Viaduct replacement project in Seattle, WA, the metro system in Los Angeles,CA and the inception of the metro system in Washington, D.C.

Parker was involved in the pioneering development of steel-fiber reinforced shotcrete, improved geotechnical tunnel investigation methods and monitoring techniques, and innovative tunnel linings and tunnel support materials.

Through his participation in the National Research Council of the U.S. National Academies of Sciences, Parker provided valuable insight into promoting the topics of tunnel security, life-cycle costing, sustainability, and risk analysis. On the global stage, he was a champion in elevating the status and contributions of the tunneling and underground industry to the international community at the United Nations.



Harvey Parker received the ITA Lifetime Achievement Award.

In addition to his geotechnical expertise, Parker consulted on issues involving general tunneling design, environmental topics, risk management, planning, cost, public relations and safety issues from an international perspective. He was primarily engaged as a member of a board, as an expert, or in a senior review capacity on the planning, design and construction of major facilities for highway, transit, railroad, water and waste water, hydroelectric, port, defense and development of surface and underground schemes in more than a dozen countries. Through his publications, he enhanced the education, training, and professional practice of those in the industry, as well as advanced the state of the tunnel and underground engineering practice. He was a Fellow of the American Society of Civil Engineers (ASCE), a member of SME and the Moles and was registered as a civil and a geotechnical engineer. He held a Diplomate in geotechnical engineering from ASCE.

Parker's passion was the advancement of the profession of tunnel and underground engineering. He served as president of the International Tunneling and Underground Space Association (ITA) for three years (2004-2007) and represented ITA at the United Nations. He also served as chair of the UTRC, USNC/TT and ACI underground shotcrete committees. He helped develop engineering staff and new markets for several firms. In 2019, Parker received the ITA's Lifetime Achievement Award, and he received the UCA of SME's Lifetime Achievement Award in 2018.

Parker's legacy has made an indelible impact on those who have had the privilege of knowing him and working with him, and his contributions will be available to future generations who pursue a career in the tunnel and underground industry. He is survived by his wife, Karen, and daughter, Erica. ■

Down for That expands website

UCA of SME announces the launch of Down for That (downforthat@smenet.org), an expanded website targeted to the next generation of underground engineers.

Visit undergroundcareers.org and see what the Underground Construction Association (UCA) is doing to raise awareness of careers in tunneling and underground construction. See what is happening underground around the world.

Check out the resources for engineering students and professors. Underground professionals can learn more about contributing materials, offering tunnel tours and becoming a speaker. Help the cause by contributing presentations, videos and case studies. Share your career story.

Tell us how you would like to contribute at undergroundcareers.org/underground-professionals. ■

UCA seeks nominations for the Executive Committee

The UCA Division seeks recommendations and nominations from all UCA members of interested individuals to serve on the UCA Executive Committee for the term 2021 to 2025. 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, 2020. 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. ■

EXECUTIVE COMMITTEE

(Continued from page 51)

has also worked for Losinger/Ebasco S.A., Healy, Frontier-Kemper and Kiewit.

ERIKA P. MOONIN, P.E., D.WRE, is a licensed professional engineer in the states of Nevada and California. She graduated from the University of Nevada-Las Vegas with a bachelor of science degree in civil engineering. She started her career working for an engineering consulting firm and now has more than 24 years of experience working for the Las Vegas Valley Water District and the Southern Nevada Water Authority (SNWA). She also has volunteered for the past 25 years for the American Society of Civil Engineers, serving in many local branch, regional and national board committee positions.


MOONIN

As the engineering project manager for the SNWA's Lake Mead Intake No. 3 project, Moonin is responsible for leading an integrated team of professionals and for managing the planning, procurement, design and construction of the Lake Mead Intake No. 3 contracts. These involve complex underground construction, heavy civil construction, alternate delivery methods and custom-designed, deep-set submersible pumps. ■

Personal **News**


ROMERO

McMillen Jacobs Associates has announced that **VICTOR ROMERO** (SME) PE, CPEng, has been elected president of its Underground Division. He now leads the division's executive management, strategy and operational functions. **DAN ADAMS** (SME), past president of the Underground Division, will continue to serve with the company, leading the development of new projects and staff. Romero has been with the company for nearly 30 years, providing leadership and underground engineering in the water, waste water, highway and rail-transit sectors. He has served in a number of leadership roles, including leading the firm's expansion in Australia and New Zealand.

MATT LYONS has joined Brokk as its newest training and application specialist. Lyons joins a highly skilled team of six training specialists who have more than 165 years combined experience. Based in the northeast, he will provide on-site and virtual safety and application training for customers in a variety of operations including interior and top-down demolition, road and bridge repair, and confined-space operations. Before joining Brokk, Lyons spent 25 years as an operating engineer based in Boston, MA, where he gained extensive experience with several models of Brokk machines. ■


LYONS

North American Tunneling 2020 Proceedings

2020, edited by Brett Campbell, Paul Madsen, Jim Rush, Matthew Preedy, and Dawn Dobson Markman, SME eBook only, 832 pp. $99 member, $79 student member, $199 list. https://www.smenet.org/publications-resources/store/sme-book-catalog

Because of the COVID-19 pandemic, NAT 2020 was held virtually to ensure the safety and well-being of industry professionals. However, to continue the intent of the conference and proceedings, the proceedings are being made available electronically.

This year's proceedings deliver the knowledge and technical detail you are searching for. Crafted from a collection of 87 papers written by experts and leaders in the industry who share their expertise, real-world applications, and lessons learned from around the globe, this book takes you deep inside today's projects.

The e-book includes challenging design issues, a fresh approach to performance, future projects and industry trends, as well as ground movement and support, structure analysis, risk and cost management, rock tunnels, caverns and shafts, TBM technology, and water and waste water conveyance.

The overarching goal is to enhance and improve future industrial underground projects and successes using applicable information presented within these published proceedings. ■

CSM's Center for Underground launches online certificate program

A new online graduate certificate program at Colorado School of Mines will prepare working professional engineers to transition their career into the specialty of underground construction and tunneling with three signature courses needed to work in the complex, interdisciplinary industry.

Launching in spring 2021, the Underground Construction and Tunnel Engineering (UCTE) Online Graduate Certificate will address the unique needs of this fast-growing, global industry.

"Urbanization is driving underground development," said Mike Mooney, Grewcock Chair Professor of Underground Construction & Tunneling and Director of the UCTE graduate program. "Underground provides huge opportunity to make cities livable. By providing this new certificate option to engineering professionals, we will enable them to gain specialized skills in a thriving industry."

The core courses in the two-semester, 10-credit program will be comprised of three signature courses delivered by faculty from three departments: Civil and Environmental Engineering, Geology and Geological Engineering and Mining Engineering. Underground Construction Engineering in Hard Rock and Underground Construction Engineering in Soft Ground are the certificate anchor courses, teaching UCTE in hard rock and soft ground, respectively. The Underground Construction Engineering Management course will teach construction management principles specifically for UCTE projects.

"UCTE is an interdisciplinary mix of structural, geotechnical and construction disciplines from civil engineering, excavation and material handling from mining engineering, and ground/ground water characterization from geological engineering" said Mooney. "Our UCTE graduate program blends the key components from our civil, mining and geological engineering degree programs."

The UCTE Online Graduate Certificate program is targeted to recent graduates who wish to expand their knowledge base and employment opportunities, as well as working professionals who recognize the need to specialize in underground construction and tunnel design given the high industry demand and the complexity of projects. Applications for spring 2021 will be accepted through Jan. 4, 2021.

For more information, visit https://online.mines.edu/program. ■

COMPILED BY JONATHAN KLUG, DAVID R. KLUG & ASSOCIATES

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark	NJ	Subway	14,600	24.5	2022	Awaiting funding
2nd Ave. Phase 2	NYC-MTA	New York	NY	Subway	16,000	20	2021	Under design
2nd Ave. Phase 3-4	NYC-MTA	New York	NY	Subway	89,600	20	2022-27	Under study
Kensico-Eastview Connection Tunnel	NYC-DEP	New York	NY	Water	10,500	27	2024	Under study
Flushing Bay CSO	NYC_DEP	New York	NY	CSO	13,200	20	2026	Under study
Bay Park Conveyance Project	NY DEC	New York	NY	CSO	18,500	8	2020	RFQ submitted
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Rail	25,000	30	2022	Under study
Metro Tunnel Program - Northern	Boston MRWA	Boston	MA	Water	23,760	10	2027	Under study
Metro Tunnel Program - Southern	Boston MRWA	Boston	MA	CSO	50,160	10	2028	Under study
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2024	Under design
Narragansett Bay CSO Phase III - Pawtucket Tunnel Conveyance Tunnel	Narragansett Bay Commission	Providence	RI	CSO	13,000 8,800	28 10	2020 2024	Short list Announced Under design
Amtrak B&P Tunnel	Amtrak	Baltimore	MD	Rail	40,000	32	2021	Awaiting funding
Alex Renew Long-Term Control Plan	City of Alexandria	Alexandria	VA	CSO	10,500	20	2019	Short list announced
Potomac River CSO Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	24,000	18	2022	Under design
Superconducting Maglev Project - Northeast Corridor	TNEM/BWRR	Washington	DC	Rail	146,520	43	2021	Under design
Lower Olentangy Tunnel	City of Columbus	Columbus	OH	Sewer	17,000	12	2020	Bid date 09/15/2020
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2019 2020	Under design Under design
Shoreline Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,100	21	2021	Under design
Shoreline Consolidation Tunnel	NEORSD	Cleveland	OH	CSO	11,700	9.5	2021	Under design
Southerly Storage Tunnel	NEORSD	Cleveland	OH	CSO	18,350	23	2024	Under design
Big Creek Storage Tunnel	NEORSD	Cleveland	OH	CSO	22.450	18	2029	Under design
Northside Interceptor	City of Akron	Akron	OH	CSO	6,850	24	2024	Under design

Tunnel Demand Forecast

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
ALCOSAN CSO Ohio River Allegheny River Monongahela River	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	 10,000 41,700 53,900	 14 14 14	 2022 2023 2024	 Under design Under design Under design
Enbridge Line 5 Tunnel	Enbridge	Traverse City	MI	Oil	23.760	12	2020	Contractor selected
I-70 Floyd Hill Highway Tunnel	Colorado Dept. of Transportation	Denver	CO	Highway	15,840	60 x 25	2022	Under design
Stormwater Control Program	Harris Co. Flood Control District	Houston	TX	CSO	52,800	25-40	2021	Under design
D2 Subway - 2nd Light Rail Alignment	Dallas Area Rapid Transit	Dallas	TX	Highway	3,000	22	2020	Under design
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	Transit	10,500	18	2022	Under design
LA Metro Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2020	Shortlist announced
Folsom Area Storm Water Improvement	SFPUC	San Francisco	CA	CSO	4,000	12	2022	Under design
BART Silicon Valley Phase 2 Tunnel	Santa Clara Valley Transit Authority	San Jose	CA	Subway	26,400	56	2021	Under design
California Waterfix 1 California Waterfix 2	Delta Conveyance Design and Const.	Sacramento	CA	Water	39,905 403,400	28 40	2020 2020	Delayed Delayed
Yonge St. Extension	Toronto Transit	Toronto	ON	Subway	15,000	18	2016	Under design
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	RFQ due April 15, 2020
Elington Crosstown West Extension	Toronto Transit Commission	Toronto	ON	Subway	40,000	18	2020	RFQ due May 29, 2020
Green Line LRT	City of Calgary	Calgary	AB	Transit	26,250	20	2018	RFQ submitted
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Traylor/Aecon JV awarded
Annacis Water Supply	City of Vancouver	Vancouver	BC	Water	7,500	15	2021	RFQ requested
Millennium Line Broadway Extenstion	Metro Vancouver	Vancouver	BC	Subway	18,700	18	2020	Short list announced
Eagle Mt. Pipeline	Fortic BC Woodfibre	Vancouver	BC	Oil	29,500	13	2020	Short list announced
Northern Gateway Hoult Tunnel	Enbridge Northern	Kitimat	BC	Oil	23,000	20	2014	Under design

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

Ad Index

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CLEAN RIVERS PROJECT, WASHINGTON, DC
METICULOUSLY UPGRADING THE UNDERGROUND
The new 20 kilometers of tunnel is aiming to reduce 96 % of untreated sewage discharge in the city of Washington, DC. Herrenknecht Four EPB Shields are building a tunnel system to separate polluted and storm water to one of the largest wastewater treatment plants in the world. Through careful monitoring the Herrenknecht TBMs are able to navigate the underground of the city.
› herrenknecht.com/cleanrivers
dc water is life
SKANSKA Jay Dee
HERRENKNECHT
PARSONS BRINCKERHOFF
GREELEY AND HANSEN
JACOBS ASSOCIATES
epc
DC WATER FIRST STREET TUNNEL
Client:
› DC Water
Contractor:
› North East Boundary Tunnel – Salini Impregilo / Healy JV
› First Street Tunnel – Skanska / Jay Dee JV
› Anacostia River Tunnel – Salini Impregilo / Healy / Parsons JV
› Blue Plains Tunnel – Traylor / Skanska / Jay Dee JV
PIONEERING UNDERGROUND TOGETHER
HERRENKNECHT
Tunnelling Systems