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2019 RETC recap

Design procurement for the Amtrak Hudson project

LA Metro Regional connector transit project

Special Editorial Supplement from the publisher of Mining engineering


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Special editorial section from the publisher of Mining Engineering

Looking ahead to the next two years for the UCA of SME

What an honor it is to take up the gavel as the chair of the UCA of SME Executive Committee after Mike Roach. He has been a steady hand that has galvanized our association in its efforts to engage with more students and young people in our industry. UCA is working hard to make students aware of the opportunities and great camaraderie and sense of achievement that a career in tunneling brings.

I hope to continue that focus and bring the vision to fruition. The executive committee is passionate about investing more in the young members of our industry, and the young members are doing a great job of demonstrating their commitment to developing their own experience and that of others.

In addition to continuing the great work of the UCA, I have three areas of focus for my two-year tenure as the chair:

1. A focus on listening to what the industry needs and wants from the UCA and setting out a clear pathway of action items to achieve those goals.
2. A focus on getting more volunteers engaged in UCA activities so we can achieve our goals in a reasonable and practical timeframe.
3. Provide clear and transparent feedback to the industry about what the UCA is doing on behalf of the members.

To this end, we will soon issue a member survey to gather information on the preferred priorities of the industry. This survey will seek to identify areas of strength and weakness in the UCA activities and will gather ideas for improving our practice.

I recently hosted a conference call with more than 60 prospective volunteers to identify specific areas where these volunteers could apply their time and effort on behalf of the UCA initiatives. The feedback before and after this call has been positive and I am optimistic (as always) that these efforts will lead to industry guideline documents and other initiatives that will benefit the tunnel industry.

I would very much like to see an increase in the number of guidelines documents the industry produces. ITATech has been a good model for identifying and then creating and publishing guideline documents. There are any number of industry-wide issues rattling around the discussions in meetings and conference rooms across the United States that would benefit greatly from an industry voice being present in the room in the form of a guideline document.

Finally, feeding back information to the UCA members who give their dues and sponsorship money, time and effort to various causes is critically important for a membership that is engaged and cares so much about how the fruits of their labor are benefitting the industry they love.

"What is the UCA doing with our money?" This is a valid question from our members that we must be prepared to answer. The UCA has to do better in distributing the results of our collective efforts to the industry at large. Under the leadership of Roach, we have initiated several major efforts to engage and train professors, students, and young members. We constantly seek to create a better link and gain more benefits from the UCA representation to the ITA. These efforts will continue and be redoubled under my watch and I intend to be clear about what we are doing and the intended benefits to the industry from UCA activities. I encourage you all to bring forward your voice.

The UCA of SME is actively supporting and helping the industry move forward. Come with us. I am more than happy to welcome you to our ever-expanding group of industry volunteers. ■

Robert JF Goodfellow,
UCA of SME Chairman

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Costs for Metro Line in Los Angeles could soar to $13 billion

A report from the Los Angeles Metropolitan Transportation Authority found that the price tag for a rail line or monorail alternative to the 405 Freeway between the San Fernando Valley and the Westside could end up being between $9.4 billion and $13.8 billion.

The *Los Angeles Times* reported that the price tag is much higher than previous estimates for the project. The estimated shortfall of billions of dollars is a significant hurdle for one of the most ambitious and long-awaited transit projects in L.A.'s modern history.

The Sepulveda line is scheduled to open in 2033, but it is one of eight projects that Metro's directors hope to finish before the 2028 Olympic Games in Los Angeles, CA.

The Metropolitan Transportation Authority (Metro) is studying four potential routes, three are subway lines and one is a monorail. All options would carry riders between the Valley and the Westside in less than half an hour, far faster than driving during rush hour.

A 20-km (12.8-mile) subway tunnel would be the fastest trip, at 16 minutes; the monorail would be slowest, at 26 minutes.

The *LA Times* reported that the project has about $5.7 billion earmarked from Measure M, the sales tax increase that county voters approved in 2016. Metro officials said they will seek federal and state grants to make up the funding gap and are considering a partnership with one or more private-sector firms to whittle down the project's costs.

Since Metro officials planned the Measure M budget in 2015, the cost of the Sepulveda project has risen because of the length of the route — most, if not all of it, underground — and a 4.8-km (2-mile) extension to a Metrolink station in Van Nuys, officials said.

"That was an estimate that was put together very early on ... [when] very little was known," said Peter Carter, Metro's deputy manager for the line. "We now have more information."

Costs of tunneling in densely occupied Southern California is high because of high costs for labor and material. The project's tunnels could be more than 21 km (13 miles) long.

"The Sepulveda line's travel times and very high ridership estimates would make a strong case for state and federal grant funding," said Juan Matute, deputy director of UCLA's Institute for Transportation Studies. The project will improve travel times for commuters and will connect the jobs-rich Westside to neighborhoods in the Valley where housing is more affordable, he said.

Grants can cover about half the cost of major rail lines in Los Angeles. The most expensive recent project — the $9-billion Purple Line

(Continued on page 18)

Maryland gets $125 million federal grant to expand Howard Street Tunnel

Maryland Gov. Larry Hogan on July 22 announced that Maryland will receive $125 million in federal grant money to support a joint project with CSX Corp. to expand the Howard Street Tunnel. However, the grant is far less than what the state asked for.

The funding under the Infrastructure for Rebuilding Grant Program will support a project that will eventually allow double-stacked containers through the tunnel and help break the rail bottleneck before the Port of Baltimore. In March, state officials asked the federal government for $228 million.

"For years, our administration has pursued funding for this critical project, and after a number of roadblocks, we are finally able to move forward on reconstruction," Hogan said. "This grant will help us to break a coast-wide bottleneck, further bolstering our economic success at the Port of Baltimore and across the state. I want to thank the U.S. Department of Transportation, CSX and our partners at the Port for making this initiative a reality."

Height restrictions in the tunnel prevent double-stacked containers from reaching the port. Double-stacking containers is more cost-effective and leads to less interstate congestion and less air pollution.

CSX and the state have committed $270 million to the project.

For years, reconstruction of the Howard Street Tunnel to accommodate double-stack, intermodal trains was believed to cost between $1 billion and $3 billion and be highly disruptive to the surrounding community. By utilizing recent advances in construction technology, CSX and Maryland Department of Transportation have determined it is now possible to provide double-stack clearance in the tunnel and under 22 bridges between Baltimore and Philadelphia for $466 million with minimal impact to the surrounding communities. CSX and the state have committed a combined minimum of $238 million toward this effort, with $147 million from the state and $91 million from CSX, and the state is seeking federal funds for the balance of the project cost. ■


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Seattle's Battery St. Tunnel to be used for utilities

With the opening of the SR-99 tunnel in Seattle, WA, the Battery Street Tunnel is now undergoing a reclamation phase, one that recently reached another milestone.

The Washington State Department of Transportation (WSDOT) reported that crews have, for the most part, completed phase one of the filling-in process and will now focus on installing utilities like sewer and electrical infrastructure, in the tunnel.

Instead of digging into existing streets, crews can layer in vaults, duct banks and sewer lines before filling in the space around them, according to WSDOT.

"Essentially, the Battery Street Tunnel is becoming a new utility corridor," WSDOT spokesperson Laura Newborn told *K5News*.

Utility work has been going on for some time and is expected to last several more months.

Phase one of the project had workers pouring crushed rubble from the Alaskan Way Viaduct into the Battery Street Tunnel using vents on surface streets. Workers poured and packed the concrete rubble into the tunnel until it was filled about 2 m (7 ft) from the ceiling.

However, there may need to be additional gravel reinforcement for some of the utilities in the future, according to Newborn.

After the utilities are in place, crews will move onto the final stage of the project, which includes pouring low-density cellular concrete into the tunnel from the top. That mixture will fill in gaps at the top of the tunnel.

Meanwhile, crews are also demolishing the southern portion of the viaduct from South King Street to South Dearborn Street, according to a WSDOT tracker.

Most of the demolition work on the central waterfront is complete or in the final restoration stage, although there are several sections of the structure near Pike Place Market that have not been torn down yet. ■

Three Chinese companies sign on to construct Tallin-Helsinki Tunnel

Finest Bay Area Development, a Chinese-funded Finnish company working on a Tallinn-Helsinki undersea tunnel project, said it will work with three Chinese companies on the final design and building of the 100-km (60-mile) tunnel, which forms part of Beijing's Belt and Road initiative.

The company said it signed a memorandum of understanding with China Railway International Group, China Railway Engineering Co., China Communications Construction Co. and financier Touchstone Capital Partners for the project.

"The partner companies are the largest in the world in their own fields of expertise," said Peter Vesterbacka, co-founder of Finest Bay Development company.

Reuters reported that the new partners were needed as Finland and Estonia had limited resources in tunnel boring and high-speed train technologies, he said.

In March, the project got a provisional 15 billion euros ($16.9 billion) from China's Touchstone Capital Partners. Roughly 12.5 billion euros will go into construction.

Beijing's Belt and Road initiative seeks to link China by sea and land with southeast and central Asia, the Middle East, Europe and Africa, through a network along the lines of the old Silk Road as well as through an Arctic route.

Finland and Estonia have for years considered linking their capitals, which are divided by the Gulf of Finland. The tunnel would cut the travel time to 20 minutes from the two-hour ferry ride, conducted by thousands of people daily.

A 2017-published feasibility study commissioned by the two governments said the planned tunnel could open in 2040 but the builders said it could be built by the end of 2024, with some parts opening already before.

The project is yet to secure backing from the two governments. ■


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Robbins EPB breaks through at Emisor Oriente

On May 23, 2019, a celebration was in order: The last of six 8.93-m (29.3-ft) diameter earth pressure balance (EPBs) machines had completed excavation at Lot 4 of Mexico City's Túnel Emisor Oriente (TEO), a feat marking the completion of 10 years and 62.1 km (38.6 mile) of tunneling.

"We are proud of having successfully finished the excavation, despite all the adversities we faced, such as large inflows of water, hydraulic loads and constant changes in geology. We solved these by adapting the excavation mode according to each type of geology found," said Hector Arturo Carrillo, Machinery Manager for Lot 4 contractor Carso Infraestructura y Construcción (CARSO).

On May 23, 2019, a Robbins 8.93-m (29.3-ft) diameter EPB completed the final lot of Mexico City's Tunel Emisor Oriente.

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Despite multiple challenges, the operation achieved a project record of 30 m (98 ft) in one day, and a high of 528 m (1,732 ft) in one month. It's a result that, Carillo said, has much to do with the continuous conveyor system being used for muck removal: "It should be noted that our advance rates were achieved thanks to the great Robbins conveyor design. The tunnel conveyor was composed with elements such as the booster, vertical belt, curve idlers, and advancing tail piece, as well as elements on the surface. Personally, I think it is a great, admirable system that has helped us achieve the tunnel boring machine (TBM's) performance."

The breakthrough was the latest and greatest milestone for an urgently needed waste water project that spanned some of the most difficult geology ever encountered by EPBs. The 10.2 km (6.3 mile) long Lot 4, running from Shaft 17 to Shaft 13 at depths of up to 85 m (280 ft), included sections of basalt rock interspersed with permeable sands with high water pressure.

"Our machines had to go through the worst geology, but they were designed for it," said Roberto Gonzalez Ramirez, general manager for Robbins Mexico, of the three Robbins EPBs and continuous conveyor systems used on Lots 3, 4, and 5 of the project.

All of the machines were designed for water pressures from 4 to 6 bars, with mixed ground, back-loading cutterheads to tackle variable ground conditions. High pressure, tungsten carbide knife bits could be interchanged with 43-cm (17-in.) diameter carbide disc cutters depending on the geology. Other features included man locks and material locks designed to withstand pressures up to 7 bar, a redesigned bulkhead, and Hardox plates to reinforce the screw conveyors as well as removable wear plates to further strengthen each screw conveyor flight. The rotary union joint was redesigned to improve cutter change times during cutterhead interventions, while a new scraper design offered more impact resistance in mixed ground conditions with rock.

The Lot 4 TBM was assembled in the launch shaft No. 17 and commissioned in August 2012, with the bridge and all the back-up gantries at the surface. Two months later in October 2012, after advancing 150 m (490 ft), the machine and its back up were completely assembled in the tunnel. One month later, the continuous conveyor system was installed and running.

After 405 m (1,328 ft) of excavation, the presence of rocks,

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GLOBAL HEADQUARTERS • (412)-963-9071 • PITTSBURGH, PA USA • WWW.JENNMAR.COM scrapers, parts of the mixing bars and other wear materials in the excavated muck prompted a cutterhead inspection. With high pressure up to 3.5 bars, it was determined that a hyperbaric intervention was necessary, and on June 2, 2013 the first hyperbaric intervention through an EPB in a tunnel was performed in Mexico. However, these interventions were done at great cost and proved to be time-consuming. After about 50 hyperbaric interventions, the remainder of the project's interventions were done in open air.

"The interventions carried out in atmospheric mode were the biggest challenge. The great influx of water tested the limits, because we were excavating on a decline. In all of these interventions we had to implement a double pumping system, at both the TBM and the shaft," said Carrillo. Despite the challenges of pumping water at volumes up to 180 L (48 gal) per second and cleaning fines from the tunnel each time the operation was performed, atmospheric interventions were still lower in cost and quicker than those done at hyperbaric pressure. ■

Robbins continuous conveyors were cited as one of the main reasons that the TBM was able to achieve steady advance in the incredibly difficult geology.

LA Connector: Four potential routes being considered

(Continued from page 4)

beneath Wilshire Boulevard — has secured about $2.75 billion in federal grants and low-interest loans, and is seeking $1.3 billion more.

Congestion pricing would also raise a vast amount of money quickly, Matute said, although charging drivers more to drive could be politically risky for Metro's elected board members. The agency has estimated that taxing drivers by the mile could raise $102 billion over a decade, while a fee to enter downtown could raise $12 billion.

The three subway options Metro is studying range in length from 20 km (12.8 miles) to 23 km (14.3 miles) and would cost $9.9 billion to $13.8 billion.

The route with the highest overall projected ridership is a subway line on elevated tracks through the Valley, then in a tunnel from Ventura Boulevard to the Expo Line. The line is expected to accommodate 137,000 daily trips and run from Van Nuys to West L.A. in 19 minutes. It would cost an estimated $9.9 billion to $12.2 billion to build, Metro said.

The two subterranean subway options under study would cost $10.6 billion to $13.8 billion to build and would carry more than 125,000 daily trips, Metro said, and a station at UCLA could be the busiest non-transfer station in the system.

Building tracks and stations above ground is significantly cheaper than excavating. But proposed aerial routes for a subway or a monorail along Sepulveda Boulevard have their own risks.

The monorail option under study would span 24.7 km (15.4 miles) and cost $9.4 billion to $11.6 billion, officials said. A monorail can handle a steeper incline than heavy rail and would be able to run at ground level for nearly two-thirds of the route, from the Getty Center to Van Nuys.

A second phase of the Sepulveda project would extend south from the Westside to Los Angeles International Airport, with a slated opening date of 2057. That line could provide a one-seat transit ride from Van Nuys to the airport in less than 40 minutes, Carter said. ■

Herrenknecht completes tunnel construction beneath Dubai International Airport

Dubai International Airport is the hub of air traffic in the Persian Gulf, as nearly 90 million international passengers are handled here each year. The operators are constantly investing in capacity expansion. As part of Dubai International Airport Expansion Phase 3, during ongoing flight operations a Herrenknecht micromachine (AVND2400AB) safely and precisely excavated three 610-, 765- and 825-m (2,000, 2,500 and 2,700-ft) long sections for a new stormwater drainage tunnel under the taxiway.

The safe and precise crossing under airport taxiways and runways is one of the disciplines of mechanized tunneling — especially when flight operations cannot be interrupted. It was crucial that heave, settlement or other impairment of this highly sensitive infrastructure be avoided at all costs. Herrenknecht tunnel boring machines in the hands of skillful tunnel builders were ideally

Passing beneath a functioning airport taxiway was a complicated challenge that was overcome on the Dubai International Airport expansion project.

equipped for this challenging task. The tunneling crew from International Foundation Group, working for Dubai Aviation Engineering Projects under the project management of M.A. Kharafi & Sons, relied on Herrenknecht tunneling technology to extend the stormwater drainage system at Dubai Airport. In March 2019, the team celebrated the successful completion of the project.

Using the pipe jacking method, an AVN machine (AVND2400AB, Ø 3,025 mm) mastered the challenge of three drives of 610, 765 and 825 m (2,000, 2,500 and 2,700 ft), respectively, under the taxiway. The result is a new drainage tunnel with a total length of 2,200 m (7,217 ft), which increases the airport's drainage capacity. At depths of 13 to 15 m (42 to 50 ft), the micromachine crossed under the Terminal 2 taxiways while flight operations on the ground and in the air continued smoothly and safely. On the longest drive, an average of 15 m (50 ft) of tunnel per day were excavated through soft soils with sandstone and siltstone. The drive remained exactly on course by precise process and control technology from VMT.

The new pipelines will efficiently collect and drain away rainwater, especially during heavy downpours, so it can no longer accumulate on the surface. This is crucial to maintaining smooth flight operations. With close to 90 million passengers per year, Dubai International Airport is one of the busiest airports in the world.

In the past, Herrenknecht technology has successfully completed a number of challenging tunnel missions, such as crossing under airports. For the extension of the baggage handling system at Zurich's Kloten Airport, a Herrenknecht Mixshield (Ø 6,280 mm) excavated a 2,400-m (7,890-ft) long tunnel under the airport grounds until 2001. In 2002, an EPB Shield (Ø 6,460 mm) tunnelled under the Minneapolis-St. Paul Airport in the United States for the newly developed, 18.6-km (11.5-mile) long light rail system. In Brazil, an AVN1500 constructed a 367-m (1,200-ft) long stormwater drainage tunnel under the runway at Goiânia Airport in 2015. In 2017, two EPB Shields (Ø 6,250 mm) completed two new tunnel tubes for passenger and baggage transport with a total length of 3,842 m (12,605 ft) under the runways at Moscow Airport Sheremetyevo in Russia. During the excavation of a 4,500-m (14,765-ft) long metro tunnel in Barcelona, in 2018 a taxiway at El Prat Airport was crossed under with great success. over a distance of 70 m (230 ft). ■

Major milestone hit at Delaware Aqueduct Bypass project

The New York City Department of Environmental Protection (DEP) completed excavation of the Delaware Aqueduct Bypass Tunnel, a significant milestone in the $1 billion effort to repair leaks in the longest tunnel in the world. The tunnel boring machine (TBM) broke through a wall of shale bedrock nearly 213 m (700 ft) beneath the Town of Wappinger in Dutchess County, NY on Aug. 13. Excavation of the tunnel was completed on budget and ahead of schedule.

"I want to congratulate the engineers, project managers and local laborers who steered us toward this milestone with considerable skill and precision," DEP Commissioner Vincent Sapienza said in a release. "Holing through is a major achievement for any tunneling project, especially one as large and complex as our repair of the Delaware Aqueduct. The moment is also a reminder that much work remains to be done as we move steadily toward completing this project in 2023 and ensuring the long-term reliability of the water supply system that sustains 9.6 million New Yorkers every day."

The Delaware Aqueduct Bypass Tunnel is the largest repair project in the 177-year history of New York City's water supply system. Its centerpiece is a 4-km (2.5-mile) long bypass tunnel that DEP is building 182 m (600 ft) under the Hudson River from Newburgh to Wappinger. When the project is finished in 2023, the bypass tunnel will be connected to structurally sound portions of the existing Delaware Aqueduct on either side of the Hudson River to convey water around a leaking section of the tunnel. The 136-km (85-mile) long Delaware Aqueduct, the longest tunnel in the world, typically conveys about half of New York City's drinking water each day from reservoirs in the Catskills.

A massive TBM began to excavate the tunnel on Jan. 8, 2018. The TBM mined 3,800 m (12,448 ft) during the 582 days that it pushed eastward from its starting point nearly 274 m (900 ft) below the surface in the town of Newburgh in Orange County. According to data tracked by DEP, the machine excavated 27.3 m (89.8 linear ft) on its most productive day, 108 m (354.8 ft) during its best week, and 288 m (945 ft) during its most productive month. The TBM excavated through


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three bedrock formations, starting with the Normanskill shale formation on the west side of the Hudson River, the Wappinger Group limestone formation, and finishing in the Mt. Merino shale formation on the east side of the river. The location and condition of these bedrock formations was well documented by New York City when it originally built the Delaware Aqueduct in the 1930s and 1940s. Engineers used that historical information to design the TBM for the bypass tunnel and plan for its excavation.

A total of 2,488 concrete rings were installed by the TBM. Now that mining is finished, DEP will begin to install 4.8-m (16-ft) diameter steel liners inside the first layer of concrete. After the 230 steel liners are installed and welded together, they will be coated with a second layer of concrete. This triple-pass design will provide the bypass tunnel with structural stability and prevent leaks from occurring again in the future.

The Delaware Aqueduct Bypass Tunnel is the first tunnel built under the Hudson River since 1957, when the south tube of the Lincoln Tunnel was finished.

DEP has monitored two leaking sections of the Delaware Aqueduct — one in Newburgh, and the other in the Ulster County town of Wawarsing — since the early 1990s. The leaks release an estimated 75.7 ML/d (20 million gpd) per day, about 95 percent of that escaping the tunnel through the leak near the Hudson River in Newburgh. DEP has continuously tested and monitored the leaks since 1992. The size of the cracks in the aqueduct and the rate of leakage have remained constant over that time.

In 2010, the city announced a plan to repair the aqueduct by building a bypass tunnel around the leaking section in Newburgh and also by grouting closed the smaller leaks in Wawarsing. The project began in 2013 with the excavation of two vertical shafts in Newburgh and Wappinger to gain access to the subsurface. These shafts, 257 and 205 m (845 and 675 ft) deep respectively, were completed in 2017. Workers then built a large underground chamber at the bottom of the Newburgh shaft. T

The existing Delaware Aqueduct will stay in service while the bypass tunnel is under construction. Once the bypass tunnel is nearly complete and water supply augmentation and conservation measures are in place, the existing tunnel will be taken out of service and excavation will begin to connect the bypass tunnel to structurally sound portions of the existing aqueduct. ■

More than 1,400 professionals gather in Chicago for 2019 RETC

From June 16 to 19, more than 1,400 tunneling and underground construction professionals gathered in Chicago, IL for the bienial Rapid Excavation and Tunneling Conference (RETC). There, they were greeted by a full technical program and an exciting exhibit hall that provided a comprehensive look at the world's bustling tunneling and underground construction industry.

The successful conference was a reflection of the industry itself, which is to say, busy. As much of the world has begun to focus on creating a cleaner and greener environment, the global tunneling industry has seen an uptick in infrastructure projects move from design-build to construction phase. With a global shift away from the use of fossil fuels, major cities around the world are looking

by William Gleason, Managing Editor

There were 21 technical sessions during the 2019 RETC Conference in Chicago, IL, June 16-19.

to increase public transportation options, which leads to the need for more transportation tunnels. And as urban populations continue to grow, the need for clean water calls for more tunnels, and as urban footprints continue to expand, the need to increase and update combined sewage overflow tunnel grows with them.

During two and a half days, more than 20 sessions covering all of these topics were presented at the Hyatt Regency in Chicago, many to packed rooms in which every seat was taken and people were standing along the side and back walls.

RETC is a biennial conference and one of the largest in the North America for the tunneling and underground construction industries. As such, it hosts a robust exhibit floor. This year 172 vendors occupied 205 booth spaces. The exhibit included everything from tunnel boring machine manufacturers, like Robbins and Herrenknecht, to the companies that supply all kinds of parts and services to the industry.

Robert Goodfellow, 2019-2021 chair of the UCA of SME, was one of the attendees who was busy throughout the week, going from one meeting to another while trying to take some time to visit the exhibit hall and sessions..

"The networking was top-notch, as usual," Goodfellow said. "Everyone was there who I needed to meet with and that's really the primary function for me. To be able to take the opportunity to be able to meet all the people and for everyone to be in same place is really great and really helpful."

Goodfellow helped kick off the conference by hosting a panel discussion, "Complex underground

There were 172 exhibitors in 205 booths during the 2019 conference.

infrastructure programs — setting the tone for program success" on Sunday afternoon. The discussion was created to help owners set a tone for successful programs and projects and included the perspective of owners, engineers and contractors.

Technical sessions began on Monday morning. One of the more popular sessions was for a presentation titled "Design and construction procurement of the Amtrak Hudson Tunnel project," from Philip Rice, vice president WSP USA. That paper is featured in this issue, begining on page 35.

The Amtrak Hudson Tunnel project is a roughly $13-billion proposed tunnel project that would create new tunnels to replace the current tunnels linking New York and New Jersey beneath the Hudson River. Those tunnels were built in 1910 and are in desperate need of repair after suffering damage from flooding caused by Superstorm Sandy in 2012.

While RETC was taking place in Chicago, legislatures in New York and New Jersey approved the formation of a bi-state commission to handle the finances for a new commuter-rail tunnel.

Lawmakers in both states passed an identical bill, titled the Gateway Development Commission Act, that would create an entity to take over oversight of the roughly $13 billion proposed tunnel. The Gateway Development Corp., a nonprofit that was an early overseer of the project, lacks the authority to accept federal construction grants.

The bill required signatures from governors Andrew Cuomo and Phil Murphy. Murphy expressed support for the bill. "The efforts of the New Jersey and New York legislatures to fully stand up a bi-state commission to oversee the Gateway Program is just the first step toward ensuring its timely and efficient delivery," he said in a statement.

Cuomo, calling Gateway the "most urgent infrastructure project in the country," said passage of the bills in both states will "take us one step

RETC 2019 hosted a number of well-attended networking events.

closer to delivering a crucial project for our nation's economy and security while restoring our role as a global leader in infrastructure."

The project is one of many that is in the planning and design stages in the United States. Other projects that were discussed included the Regional Connector Transit Corridor project in Los Angeles, CA, the Don River & Central Waterfront Coxwell Sanitary Bypass tunnel project in Toronto, ON, Canada and the Times Square Shuttle Stations and Reconstruction project.

The sessions about future projects (or potential future work for industry professionals) were among the best attended sessions. But the conference was not limited to major projects or to projects in North America. Among the sessions were environmental health and safety, design and planning, SME/NATM, pressure face TBM technology, tunneling for sustainability, contracting practices and cost, drill and blast, difficult ground, new and innovative technologies, design/build projects, large span tunnels and caverns, hard rock TBMS, geotechnical considerations, future projects, shafts and mining, grouting and ground modification and ground support and final lining.

Robert Goodfellow, (l) 2019-2021 Chair, presents the Past Chair plaque to Mike Roach, UCA of SME chair, 2017-2019.

Keynote

During the Welcoming Luncheon, Andy Alder, program director for the Tideway project in London, shared an overview of the massive project that is underway beneath the Thames River in London.

As with many major cities, London has far outgrown much of its infrastructure over the years, leading to the need to update its sewer tunnels. The Tideway project consists of 25 km (15 miles) of tunnels that will prevent tens of millions of tons of pollution that currently pollute the River Thames.

Planning of the project was approved in 2014 and tunneling began in 2018. The project is using six tunnel boring machines.

Alder spoke of the history of London and the existing tunnels and need to improve the tunnels.

In the latest annual report on the project, it was confirmed that the project remains on schedule.

The report also outlines how Tideway is working to keep the environmental impact of construction to a minimum — by using the river instead of the road network to transport material to and from the site. It is taking around 200 truck journeys off the road each day.

Alder also spoke of the positive environmental and health safety impacts of the project. He said it is estimated it has avoided more than 115,000 truck journeys in total by carrying more than one million tonnes of material on barges instead, which it has calculated produce around 90 percent less carbon dioxide than an equivalent truck.

Andy Mitchell, Tideway CEO, said in a statement: "By transporting at least 90 percent of our tunneling material by river instead of on the road, we are reducing our carbon footprint, as well as reducing road safety risks in London — two key issues for the capital. We are confident our work will lead the way in how businesses in the future consider sustainable options for transporting goods and materials.

"While our ultimate goal is to clean up the River Thames, we're also committed to boosting the river economy, increasing jobs and improving safety standards."

Exhibit floor

While the technical sessions provide an opportunity to share best practices, the exhibit floor also provided a forum for professionals to speak about the industry. With more than 172 exhibitors, the scope of the industry was well-represented in the exhibit hall.

"I did walk around the exhibition a fair amount and that was very high quality," said Goodfellow. "There were a lot of interesting exhibitors

The exhibit hall provided an opportunity for vendors to network with conference attendees during the 2019 RETC.

with really good information … to have the suppliers in the same room with the engineers and the contractors is a benefit to everyone."

Social functions

In addition to the technical sessions and exhibit floor, attendees of RETC 2019 were able to mingle and network at a host of social functions including receptions for the Women in Tunneling, UCA of SME Young Members and an owners forum.

Cutting Edge

From Nov. 18-20, 2019 the industry will gather again at the eighth annual Cutting Edge Conference in Miami, FL. Like RETC, the conference includes technical sessions and opportunities for professional networking.

Organized in partnership with *North American Tunneling Journal* and the UCA of SME, the Cutting Edge Conference features a tailored, high-end, single-track program of subject-specific presentations that focus on innovation and practical experience, as well as extended in-depth industry discussion sessions – which have become a trademark of this conference.

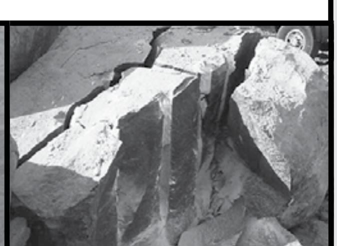
In conjunction with the Cutting Edge Conference, the International Tunnelling and Underground Space Association will present the 5th edition the ITA Tunnelling Awards on Nov. 18 in Miami. ■

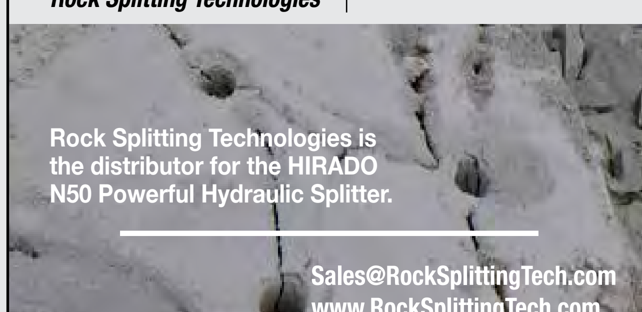
Coming Events

Cutting Edge
Nov. 18-20, 2019
Hilton Miami
Miami, FL, USA

George A. Fox Conference
Jan. 28, 2020
City University of New York
New York, NY, USA

More information: Meetings Department, SME, phone 800-763-3132, 303-948-4200, fax 303-979-4361, email sme@smenet.org **www.smenet.org/full-calendar**



Design and construction procurement for the Amtrak Hudson Tunnel project

FIG. 1

New Hudson River Tunnel alignment.

The Gateway Trans-Hudson Partnership (GTHP), a joint venture of WSP USA, Inc., AECOM USA, Inc, and STV Incorporated, is providing preliminary engineering services to Amtrak for the Hudson Tunnel project as well as supporting the NEPA process for getting the record of decision (ROD). This preliminary engineering design effort by GTHP includes geotechnical exploration and laboratory testing, design of structures, tunnel contract packaging and procurement planning.

The Hudson Tunnel Project includes the construction of a new Hudson River Tunnel system and rehabilitation of the existing North River Tunnel. The new tunnel system will be constructed south of the existing North River Tunnel, from North Bergen under the Palisades to Hoboken in New Jersey, below the Hudson River, and connecting directly to Penn Station in New York (Fig. 1). The tunnel system is configured as two single-track tubes, intermediate ventilation shafts and cross passages in compliance with NFPA-130 requirements. The adjacent surface alignment west of the Palisades will be constructed on viaducts, embankment and retained fills.

Phil Rice, Richard Flanagan and Mohammed Nasim

Phil Rice, Richard Flanagan and Mohammed Nasim, members UCA of SME, are vice president, WSP/Parsons Brinkerhoff, vice president/technical director, WSP USA and TITIE, Amtrak, respectively, email phil.rice@wsp.com.

The existing North River Tunnel (Fig. 2) consists of two single-track, electrified rail tunnels extending from tunnel portals in North Bergen, New Jersey to Penn Station in New York. Completed in 1910 by the Pennsylvania Railroad, the tunnel opened at the same time as Penn Station and the four, single-track, East River tunnels that connect Penn Station to Queens and onto Long Island and New England, respectively. Both tunnels in the existing North River Tunnel were inundated with brackish river water during Superstorm Sandy (Fig. 3), resulting in the cancellation of all Amtrak and NJ Transit service into New York City for five days. After the brackish water was removed from the tunnels, the residual chlorides and sulfates have had on-going detrimental impacts on the interior concrete and rail systems.

The poor condition of the tunnels following Superstorm Sandy as well as their continuous high level of use, has highlighted the lack of a trans-Hudson River operational flexibility necessary to conduct routine maintenance and state of good repair to ensure continued Northeast Corridor (NEC) operations into Penn Station at existing peak period operating levels. Any emergency or routine maintenance in the tunnels requires outages that disrupt service for hundreds of thousands of passengers each day. An extended disruption, caused by natural or manmade disaster, would result in local, regional and national economic impacts. The susceptibility of the region to natural disasters and condition of this critical asset drives the

FIG.2 - FIG. 3

Existing North River Tunnel and flooding of the tunnels during Superstorm Sandy.

urgency to strengthen resiliency of this river crossing.

The Hudson Tunnel Project is focused on tunnel resiliency and redundancy essential to reducing the risk associated with dependency on the century-old tunnel. Once the new Hudson River Tunnel is commissioned, the existing North River Tunnel will be rehabilitated and modernized. This will include renewal of the tunnel facilities, including benchwalls, catenary, communications and signals; fire and life safety; drainage facilities, as well as maintenance and emergency egress features. The existing ballasted track and drainage systems will be removed and replaced with a direct fixation track system.

The cancelled Access to the Region's Core (ARC) Project (2010) included surface alignments and tunnels through New Jersey, under the Hudson River and into Manhattan to a new station cavern connecting to Penn Station. Most of the ARC New Jersey alignment has been utilized by the Hudson Tunnel project. This includes the surface works and Palisades Tunnels that have identical alignments as the ARC project. However, the new tunnel project Hudson River and Manhattan section alignments now differ from ARC along with a direct Penn Station connection.

The ARC Project had several construction packages where contracts had been already awarded or had been advertised and/or ready for award. Utilizing the knowledge and information that was collected during the ARC project, GTHP has utilized previous information and design and adjusted and revised contract packages previously awarded and incorporating whatever changes have been required for the new tunnel alignment.

Project location and anticipated subsurface conditions

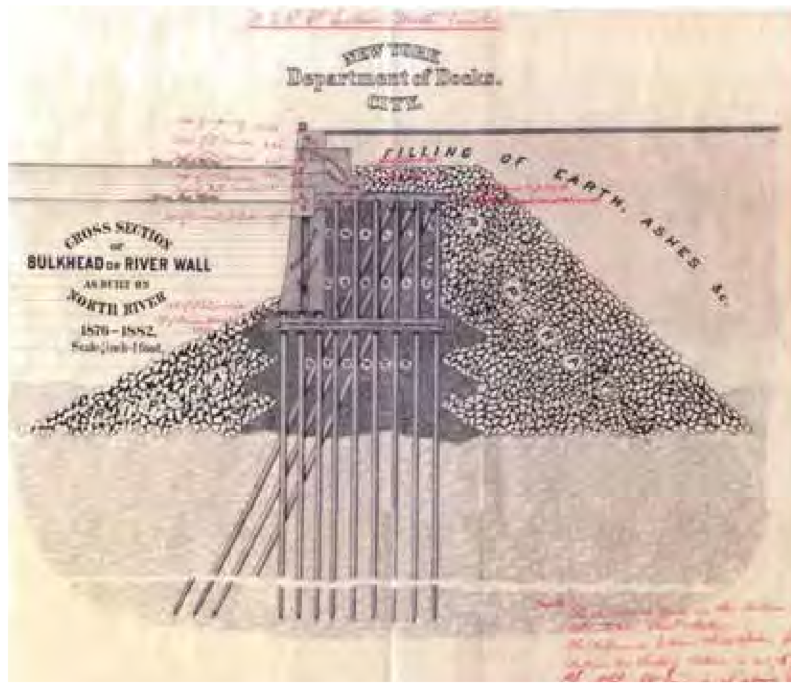
Site development and manmade obstructions. Much of the New

Jersey project area is set within the largely undeveloped, low-lying Hackensack Meadowlands. The area on the east side of Frank R. Lautenberg Station is characterized by major transportation infrastructure, including the New Jersey Turnpike and the NEC, and transmission towers. Industrial facilities such as the PSE&G Generating Station and warehouses and distribution centers are located north and south of the NEC. East of the Tonnelle Avenue arterial, the municipalities of North Bergen, Union City and Hoboken are characterized by a mix of low- and high-rise residential developments, commercial corridors and varying degrees of industrial activities.

The Hoboken and Weehawken area has increased residential development since the ARC Project was cancelled, in particular adjacent to the Hoboken Shaft area. In Hoboken, the tunnel alignment crosses two at-grade tracks of the Hudson Bergen Light Rail (HBLR) for a distance of about 121 m (400 ft). The electrified tracks were constructed in 2004. A new PSE&G substation was constructed in 2016, south of the HBLR at 19th Street adjacent to the tunnel alignment.

FIG.4

Typical Manhattan bulkhead construction.



In Manhattan, the project alignment crosses below a heliport, Hudson River Park, 12th Avenue, West 30th Street, the elevated Highline urban park and new major development above the extensive rail yards west of Penn Station. The existing Manhattan Bulkhead (Fig. 4) was built in the 1870s and consists of timber piles, concrete blocks and stone rip-rap structure approximately 45 m (150 ft) in width. The North River Tunnels were mined through the Bulkhead piles and rip-rap by using Greathead Shields with compressed air. The new tunnel alignment requires a tunnel excavation to mine through the lower portion of the Bulkhead where timber piles and rip-rap structure will be encountered. Additionally, there are three other significant underground obstacles that will need to be addressed east of the Manhattan Bulkhead: 1) abandoned concrete-filled pipe piles of the former West Side Highway, 2) a NYCDEP interceptor sewer supported by steel piles underneath 12th Avenue and 3) a NYCDEP combined sewer anticipated to be supported on timber piles underneath West 30th Street.

Anticipated ground conditions

The Hudson Tunnel project is located within the Appalachian Highlands U.S. physiographic division. The project crosses two distinct physiographic provinces.

The New Jersey portion of the project region is located within the Piedmont Lowlands section of the Piedmont physiographic province, a broad lowland interrupted by long, northeast-trending ridges and uplands. The most prominent physiographic feature in the eastern part of the section is the Palisades, a north-south topographic ridge near the Hudson River that rises above the surrounding lowlands of the Meadowlands.

The New York portion of the project region is located within the Manhattan Prong of the New England Upland section of the New England physiographic province. Topography is largely controlled by bedrock geology. Manhattan's elongate ridges trend generally northeast.

The Hudson River portion of the project region is located between the Piedmont physiographic province to the west and the New England physiographic province to the east.

New Jersey Surface Alignment ground conditions

Five soil strata are identified in the New Jersey Surface Alignment section: Stratum F (fill), Stratum O (peat and organic soils), Stratum S (sand/silt and sand), Stratum C (varved silt/clay) and Stratum G (glacial till). The Stratum C can be further divided into two substrata, Stratum C1, an over-consolidated stiff layer and Stratum C2, a normally consolidated or slightly over-consolidated soft layer.

From Tonnelle Avenue to the east toe of the Palisades, two soil strata are identified, Stratum F (fill) and Stratum G (glacial till). From the east toe of the Palisades to the Hoboken Shaft, all five soil strata are present.

Palisades Tunnels ground conditions. The Palisades Tunnels will be excavated and bored mainly in the igneous Palisades Diabase. There is also a limited section of Lockton Formation and Stockton Sandstone. The diabase is generally fresh to slightly weathered. Tunneling rock mass quality classifies from poor to good with the latter predominant.

The Lockatong is encountered at the eastern edge of the Palisades sill and typically consists of a silty argillite, laminated mudstone, very fine-grained sandstone and siltstone and minor silty limestone. Where the Palisades Diabase sill intruded into the Lockatong Formation, it thermally metamorphosed the rock into a brittle, black, very fine-grained hornfels. Further eastward and entering the Hoboken Shaft, the Stockton Sandstone is encountered. It consists of sandstone with conglomerate and siltstone lenses. Tunneling rock quality rock mass quality is classified as very poor to poor.

The Palisades tunnels will be mined in full-face rock with generally anticipated low ground water inflows although there are some faulted zones.

Hudson River Tunnel ground conditions. In most of the Hoboken area there is fill underlain by a peaty and organic soil (O). It consists of fibrous peat mixed with dark gray, organic clay. The material is very soft to soft and classified as OH, Pt, CH and ML. Varying amounts of silt and sand are also present within this deposit. Methane gas is anticipated in this stratum.

In the Hoboken land section of the tunnel, estuarine deposits (designated E) is the primary soil stratum through which the Hudson River Tunnels will be excavated. The deposit consists of gray, silty clay to sandy silt with estimated thickness ranging from several feet to more than 61 m (200 ft). Stratum E is generally classified as high-plasticity clays (CH); however, high-plasticity silts (MH), low-plasticity clays (CL), and low-plasticity silts (ML) are also present. Small shells and organics have been encountered at various depths within Stratum E. Organic content is typically less than 5 percent.

In some locations, Stratum S locally underlies Stratum E with thickness ranging from 0.6 to 2.4 m (2 to 8 ft) and can be classified as very loose to dense silty sand (SM) or sandy silt (ML).

Glacial deposits (G) are present and will be encountered on a limited basis. The (G) soils are a heterogeneous mix of soils generally classified as CL, ML, SP, SM, SP-SM, GP, GM, GP-GM. The glacial deposits are typically reddish brown, brown or gray sands and consist of varying amounts of clay, silt, sand and gravel. Boulders are also present. Consistency and density ranges from stiff to hard and medium dense to very dense, respectively.

Parts of the Hudson River Tunnel alignment are in bedrock of different formations. Within the tunnel excavation, the Stockton Sandstone is present for about 25 percent of the entire alignment. The rock mass quality is generally rated poor to very poor. As the alignment progresses, eastward toward the Manhattan shore line, the rock type changes to Manhattan Schist. However, rock will not be encountered there since the alignment is shallow.

Mixed-face tunneling will be encountered at several locations in the Hoboken area as the tunnels proceed eastward toward the River. Approximately 1,400 feet of the tunnels, as they approach New York, have less than one diameter of ground cover in soft weak Stratum E soils. Additional design and construction considerations are required for this low cover section.

Manhattan Tunnel ground conditions. The overburden soil in the Manhattan area consists of fill materials (F) overlying saturated estuarine deposits (Stratum E), silt and clay (Stratum C), and glacial deposits (Stratum G). The overburden soils consist primarily of very soft to medium stiff clays and silts and very loose to medium dense silty sands. The glacial deposits are stiffer and denser and have the potential to contain cobbles and boulders. The overburden soils are highly compressible and will respond to minor changes in stress, such as construction surcharge loads, changes in pore pressure (due to dewatering or lowering of the ground water table from inflows into open excavations), or other changes from the initial in situ stress state.

Mined tunnel excavations by non-TBM methods in estuarine deposits will require heavy support of excavation walls due to the low strength and high compressibility characteristics of these deposits. During excavation it will also be necessary to use some form of external ground treatment to stabilize the tunnel face and supplement the excavation support systems.

Hudson Tunnel Project contract packaging development

Multiple contract packages are planned for the Hudson Tunnel Project, including contracts covering tunneling, other major underground work, civil work, and, and follow-on typical finish works consisting of internal concrete, track work, rail systems, ventilation systems and fan plant structures. The packaging plan, currently under development, will be based on several factors, including

- Project funding strategy and expected cash flow
- Types of construction and skill sets involved
- Potential contract size and attractiveness to industry
- Schedule optimization
- Contract interface risk
- Opportunities for contractor innovation
- Timing for availability of real estate / easements
- Third party / stakeholder constraint, including permitting requirements.

Contract scope components (building blocks) to be organized with some combination into the final contract packages include the following.

NJ Surface alignment. The proposed NJ Surface Alignment scope component extends from Allied Interlocking, located east of County Road in Secaucus to the Tonnelle Avenue in North Bergen, just west of the Palisades Tunnel Portal. The double track configuration will be constructed on retained embankment, aerial viaduct structure and bridge structure over the Secaucus Road and the New York Susquehanna and Western and Conrail freight tracks. This scope also includes the construction of drainage culverts, access roadways, foundations for overhead catenary structures, security fencing, access stairways and platforms for signal and communication systems structures.

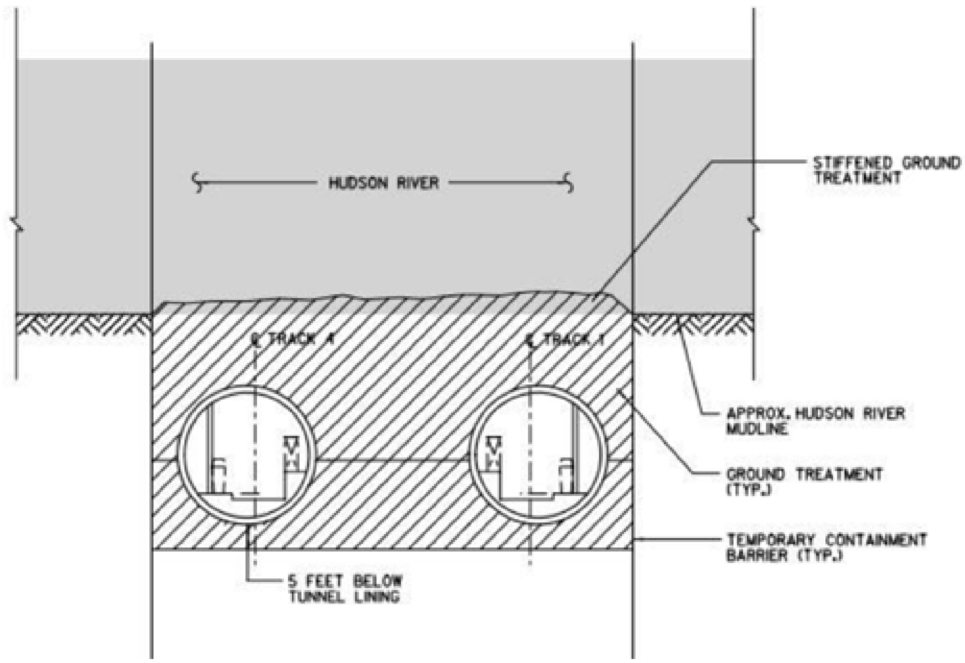
Tonnelle Avenue Overhead Bridge. This work componentwas already well under construction as a small first contract when the ARC Project was cancelled. Resumption of this work will require further excavation of the abutment walls that were previously completed and reestablishing the bearing area for the precast concrete deck beams.

This scope component also includes excavation of the backfill that was placed within the track alignment area between the abutment walls when the ARC Project work as suspended in 2010. A new drainage system needs to be installed to handle storm water in the overhead bridge area, and existing utilities below the roadway will need to be relocated.mining operation

Palisades and Hudson River Tunnels. This major tunneling scope component consists of two TBM drives from the NJ Tonnelle Avenue Portal on the west side of the Palisades, through the Hoboken Shaft

FIG.5

Ground improvement in low cover area.



This shaft will also be utilized as a future ventilation shaft. The tunnels have the option to be supported using either single-pass pre-cast concrete segments, or a two-pass lining system with temporary support and a follow-on permanent support of cast-in-place concrete with a waterproof membrane system. The number of hard rock TBMs and the selection of the tunnel lining alternative will be left to the contractor.

The Hoboken Shaft excavation will utilize slurry walls through the overburden to rock, and drill-and-blast methods to excavate the rock to the required shaft base. During shaft construction, strict ground water control will be required to prevent pore pressure changes in the highly compressible soils that would result in large settlements to nearby utilities, roadways and residences. At the shaft TBM breakout, a combination of jet grouting and rock mass rock grouting is planned.

The Hudson Tunnels segment includes all work necessary to complete two TBM tunnel drives between the Hoboken Shaft and the 12th Avenue Shaft in Manhattan. These tunnel drives include full-face rock, mixed-face and soft ground conditions. Because of the variable and range of ground conditions, the TBMs are expected to be hybrids with pressurized-face capabilities, with earth pressure balance technology most applicable. The contractor could propose to utilize the two hybrid TBMs to first excavate the Palisades tunnels with perhaps some TBM cutterhead modifications done at the Hoboken Shaft following the Palisades rock tunnel excavations before proceeding eastward under the River.

The Hudson TBMs will be removed at the 12th Avenue shaft. The last several hundred feet of tunnel would be excavated though controlled low strength cementitious backfill of previously constructed sequential excavation method (SEM) tunnels extending from the River edge, under 12th Avenue and into the 12th Avenue Shaft. This SEM section will handle the

(future NJ fan plant site), under the Hudson River and into Manhattan terminating at the 12th Avenue Shaft (future fan plant). Major elements of this scope component are:

- Palisades portal works.
- TBM power substation.
- Hard rock TBM excavation for Palisades tunnels.
- Construction of the Hoboken shaft.
- Hybrid (rock, soft ground) TBM excavation for Hudson River Tunnels.
- Pre-excavation ground treatment in the River section with low ground cover.
- Nine cross-passages in rock; six cross passages in soft ground utilizing ground freezing.

Preparatory work for the TBM operation includes the construction of a temporary TBM power substation, stabilization of the rock face supporting Paterson Plank Road in North Bergen, NJ above the excavation of the approach to the Palisades Tunnels to establish starting line and grade for the TBM and assembly of one or two hard rock TBMs with trailing gear and supporting logistics at the Tonnelle Avenue Portal.

The Palisades Tunnels section, primarily stable rock, runs from the western slope of the Palisades to the Hoboken Shaft whereby the TBMs will be received.

removal of numerous obstructions.

For the Hudson Tunnels, preparatory work for the TBM operation includes a temporary TBM power substation (if not shared with the Palisades Tunnel section), underpinning of Willow Avenue Bridge in Hoboken and some ground treatment to protect sensitive structures located in the Hoboken mixed-face areas. Some of the sensitive structures are buried high-voltage cables and the HBLRT light rail.

A section of the River tunnel, toward the New York side, has low ground cover in weak soils, resulting in potential buoyancy issues and face stability concerns during TBM mining. Hence, prior to TBM arrival in this area, ground improvement installation (in the wet) placed within a temporary containment cofferdam is needed, see Fig. 5. The current preferred ground improvement method is deep soil mixing (DSM).

Cross passages will be provided for emergency egress between tunnels and to house some mechanical and electrical equipment. The 15 cross passages for the Palisades and Hudson Tunnels will be excavated and supported using two different methods, depending on the existing soil or rock conditions.

Cross passages in rock are anticipated to be mined excavations by SEM with drill-and-blast techniques. Temporary ground support (e.g., rock dowels, shotcrete) would be used. Permanent ground support would consist of either shotcrete or cast-in-place concrete, with a waterproof membrane,

Cross passages in the soft ground or soil areas will be pre-stabilized using horizontal ground freezing techniques. Excavation would be SEM with shotcrete/lattice girders as temporary support. These cross passages would also be permanently supported with cast-in-place concrete or shotcrete with a waterproof membrane.

Manhattan Tunnels. This scope component entails much work centered around SEM tunnels through obstructions, shaft excavation, major ground stabilization measures and underpinning. All these works occur in very poor ground conditions where excavations need to be strictly controlled to mitigate ground settlements. Major work elements are:

- Construction of the 12th Avenue Shaft using slurry walls and ground improvement.
- Ground stabilization primarily by ground freezing and construction of SEM tunnels (westward) between the 12th Avenue Shaft and the Manhattan Bulkhead at the waterfront area including filling the tunnels with controlled low-strength cementitious backfill.
- Ground stabilization primarily by jet grouting and construction of SEM tunnels (eastward) under West 30th St running from the 12th Avenue Shaft to connect with West Rail Yard (Hudson Yard) Tunnels north of West 30th Street.
- Installation of a permanent tunnel lining, cast-in-place concrete with a waterproof membrane system for the eastward West 30th St running SEM tunnels.
- Building a temporary bypass for the large 100-year old two cell storm sewer running along West 30th Street directly over the tunnel alignment and then finishing with a new permanent sewer structure after the tunnels are completed.
- Several utility underpinning and reconstruction/relocations in West 30th Street and 12th Avenue areas.
- Demolition of existing structures on the 12th Avenue Shaft site (Block 675 Lot 1).

The 12th Avenue Shaft excavation will utilize slurry walls in soil overburden. Overburden consists of fill underlain by weak highly compressible silts and clays. Deeper below the shaft invert are glacial deposits and rock. During shaft construction, strict ground water control will be required to prevent the surrounding highly compressible soils from reacting to pore water pressure drops, which would result in large settlements to nearby utilities, roadways and buildings. Temporary construction flood gates will also be installed in the 12th Avenue Shaft.

Ground conditions for each SEM tunnel segment will consist of fill materials underlain by weak soft clays and silts.

The Manhattan Bulkhead is founded on timber piles with cobbles and rip-rap fill. Prior to excavation through the pile/rip-rap/cobbles, permeation grouting would be done to facilitate follow-on ground stabilization by filling rip-rap voids and locking rip-rap/cobbles in-place. Ground stabilization is planned as ground freezing. More than 115 timber piles are expected to be encountered in each tunnel crossing of the Bulkhead.

Heading west from the 12th Avenue Shaft, SEM tunnels will be utilized to remove the steel H pile foundations of a large NYCDEP sewer below the northbound side of 12th Avenue, replacing them with an underpinning structure. In addition, abandoned West Side Highway concrete filled pipe piles will be removed.

Ground improvement will be required prior to all SEM tunneling in this latter area due to poor ground conditions. However, ground stabilization in this area is planned as jet grouting.

Connection to A-Yard. The scope for making the connection to the Amtrak's existing A-Yard track network on the west side of Penn Station New York includes construction of a cut and cover tunnel under 10th Avenue with temporary utility support and permanent reconstruction; the track reconfigurations in A-Yard with associated underpinning of several support columns for the overlying building at 450 West 33rd Street (Brookfield Building); construction of the A-Yard Fan Plant structure under the Brookfield Building; and installation of flood gates on the east side of 10th Avenue

NJ fan plant and internal tunnel concrete. Construction of the Hoboken Fan Plant will follow the completion of the Palisades and Hudson River Tunnels, including the fan plant building structure and building mechanical, electrical and plumbing facilities.

The internal concrete finish work required for the Hudson River and Palisades Tunnels consists of the high and low benches, the tunnel invert, the sidewall ventilation duct wall, cross passage finish work and construction of the open cut section between Tonnelle Avenue and the Palisades Tunnel Portal.

Railroad systems

Traction power. Traction power facilities will be constructed in accordance with well-established railroad installation procedures. Each element of construction will be based on previously installed facilities. Critical constructability issues that will require refinement include the scheduling of outages with Amtrak for the connection to the existing transmission network and for the modifications required at the existing Amtrak substations.

Overhead catenary system. The project will include the installation of a complete overhead catenary system, including the supporting structures, for the entire alignment from the New Jersey surface section to A-Yard in Manhattan. It is assumed that all new catenary structures will be installed by the contractor. Amtrak forces will perform the connections to the existing NEC system at Allied Interlocking and in A-Yard.

Modification of the existing Amtrak catenary structures will need to be done as part of the Amtrak force account effort. Staging plans will need to be established with Amtrak to establish nighttime and/or weekend schedules to work at the connections and adjacent to existing tracks.

Signal work. Signal construction will follow closely after the track bed is installed. A trough for the signals and communications cables will be installed along the full extent of the NJ surface contract. Platforms will also be constructed along the NJ surface alignment for the new signals and communication structures for controlling the new Allied Interlocking.

Embedded conduits in the tunnel sections as part of the appropriate tunnel finish concrete work. Cables will be pulled into the embedded conduits or laid in the trough as part of the railroad systems work. The signal equipment installation can coincide with work on other disciplines such as electric traction and communications.

Final connections of all new signal and communications equipment are expected to be performed by the Amtrak forces.

Track work. Ballasted track construction will be consistent with common local practice. Direct fixation track construction in the tunnel sections will be based on a resilient tie design. All special trackwork materials for the new Allied interlocking will be contract procured but installed by Amtrak forces.

Fan plant MEP and electrical substation installations. The Hoboken Fan Plant, 12th Avenue Fan Plant and A-Yard Fan Plant will all be fitted out and equipped in combination to ensure system compatibility. This scope component will also include provisioning of emergency power generators at the Hoboken and 12th Avenue Fan Plants and electrical power substations to supply operating power to the fan plants.

General project schedule

The start of construction will depend on when the Project will receive a Record of Decision for the environmental review process and the availability of the required funding is secured. Once construction is underway, the project has an overall timeline of approximately eight years. After the new Hudson Tunnels are operational, the existing North River Tunnels will be taken out of service one at time for complete rehabilitation, with that work expected to be approximately three years later. At that point, Amtrak will have four tunnels in reliable operating condition, which will make possible an increase of passenger capacity with the completion of other key projects that are part of the overall Gateway Program, including an expansion of Penn Station in New York.

Conclusion

There is an urgent need for a reliable and redundant back-up for the aging existing North River Tunnels crossing the Hudson River into New York. These existing tunnels are critical to the need for reliable rail transportation and the economic well-being of the Northeastern United Sates. When the new tunnels to be constructed under the Amtrak Hudson Tunnel Project are completed and operational, they will allow the existing tunnels to be taken out of service for complete rehabilitation to resolve their on-going structural and systems deterioration issues.

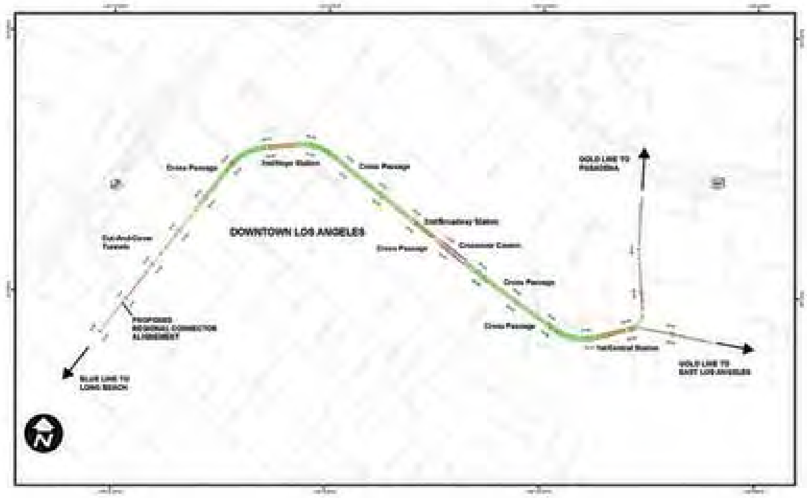
The Amtrak Hudson Tunnel Project construction is expected to be covered by a multiple contract packaging plan that is currently under development. The packaging plan will be configured to be attractive to the construction industry, reduce interface risk, and provide opportunities for contractor innovation. ■

LA Metro Regional connector transit project: Successful halfway-through completion

The Regional Connector project is a complex subway light-rail project that runs through the heart of downtown Los Angeles, CA. The design-build contract was awarded in April 2014 to the Regional Connector Constructors (RCC), a joint venture between Skanska USA Civil West California District Inc. and Traylor Brothers Inc., and their designer team consisting of Hatch Mott McDonald (HMM) and subconsultants. The project broke ground on Sept. 30, 2014 and is expected to be completed in winter 2021-2022. The main components of the project consist of 6.4-m (21-ft) diameter twin-bored tunnels, three crosspassages, a 87-m (287-ft) long crossover SEM cavern, three new underground stations, and cut-and-cover tunnels along South Flower, Alameda and 1st Streets. The project map is shown in Fig. 1. The design and construction challenges associated with each of these main components are discussed in the following sections.

FIG. 1

Regional Connector project map.



Project design

Tunnels. The Regional Connector tunnels are located primarily within the Fernando formation consisting predominantly of extremely weak to very weak, massive, clayey siltstone. About 305 m (1,000 ft) of tunnels on the eastern end are in alluvium and mixed face of Fernando formation and alluvium. The tightest curve of the tunnel alignment is 178 m (583 ft) in radius. The tunnels were designed with a reinforced precast concrete tunnel lining (PCTL) to be used with an earth balance pressurized (EPB) tunnel boring machine. The PCTL ring is 5.5 m (18 ft-10 in.) inside diameter, 27 cm (10.5 ft) thick, 1.5 m (5 ft) long, and consists of five segments and a key. The segments were designed with 6,500 psi concrete, 80 ksi yield strength wire rebar, convex joint surfaces to enhance seismic performance, and a dosage of 1.7 lbs polypropylene microfibers per cubic yard of concrete for fire resistance. The rings are designed with a right ring and left ring pattern and a taper of 3.8 cm (1.5 ft) to allow for alignment curve negotiation. Figure 2 shows typical sections of the PCTL. The structural lining design was modeled using FLAC 3D. Four consecutive rings were modeled with 32 dowel connection. Loading considered in the lining design includes temporary ground load during excavation, long-term ground loads, seismic loads and train loads. The seismic loads on the PCTL were simulated with the racking deformation applied at vertical boundaries of the model. Due to variation of geologic condition along the tunnel alignment and different surcharge requirements, three different types of reinforcement (typical, heavy and extra heavy) were designed. The typical type PCTL was required in Fernando formation, the heavy type was required in alluvium or mixed-face condition, and the extra heavy type was required in alluvium and underneath the Japanese Village Plaza where a surcharge of 1,000 psf was required.

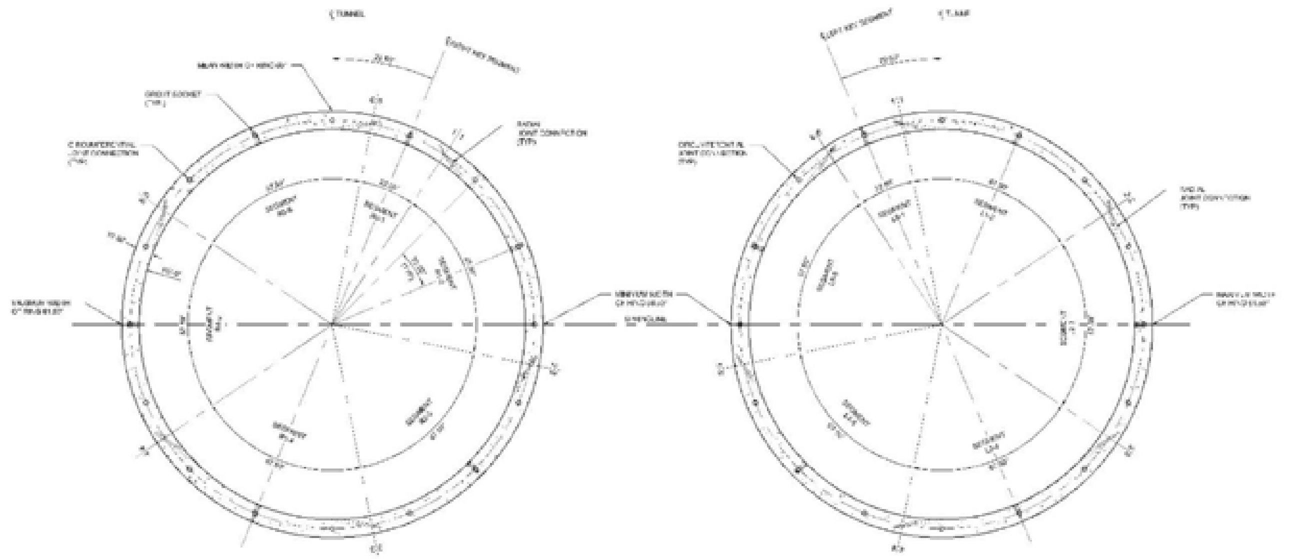
SEM cavern. A crossover at the eastern end of the 2nd/Broadway Station is required for train operation. Since the crossover is located beneath the narrow 2nd Street where the basements of the buildings on both sides were constructed beyond the property line into the sidewalks, a cut-and-cover structure is not feasible. A sequential excavation method (SEM) cavern was designed to overcome the site constraints. The SEM cavern is 17 m (58 ft) wide, 11 m (36 ft) high and 87 m (287 ft) long. It is located within the Fernando formation, with a depth of invert at 26 m (86 ft) and the crown at 15 m (50 ft) below grade. Above the cavern crown there is approximately 9 m (30 ft) of Fernando

Mike Harrington and Tung Vu

Michael Harrington and Tung Vu, members UCA of SME, are senior director-project engineering, Metro Regional Connector Project and lead tunnel engineer, VN Tunnel and Underground Inc., respectively, email harringtonM@metro.net.

FIG.2

Tunnel typical section.



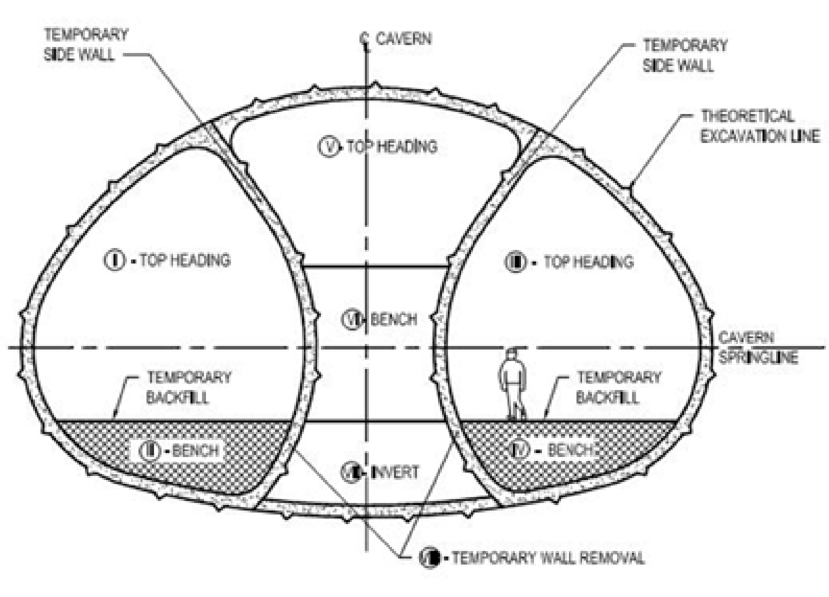
formation overlaid by 6 m (20 ft) of alluvium. The cavern was designed using FLAC 2D and FLAC 3D with all applicable loads required by Metro Rail Design Criteria (MRDC) and AASHTO 2012. The cavern was designed with right, left and central drifts with top heading and bench. Figure 3 shows a typical cross section of the SEM cavern initial lining with the numbering sequence of excavation. Both TBM tunnels were completed prior to the start of SEM cavern excavation. Since the PCTL ring is 1.5 m (5 ft) long, the SEM excavation round of 1 m (3 ft-4 in.) was selected particularly to allow removal of two PCTL rings at every three SEM advances. The SEM cavern lining consists of a 30-cm (12-in.) thick initial fiber-reinforced shotcrete lining, a hydrocarbon resistant (HCR) membrane, and a 45-cm (18-in.) thick cast-in-place concrete reinforced concrete final lining with the invert slab thickness varying from 45 to 175 cm (18 to 69 in.). The cavern also houses an emergency ventilation plenum located above and separated from the trainway by a 30 to 40 cm (12 to 16 in.) thick plenum slab.

A FLAC 3D model was first performed to simulate the SEM excavation sequence, soil properties, shotcrete lining with age-dependent strengths and adjacent structure loading. It also serves in the prediction of ground settlements above the cavern. The cavern initial and final linings were analyzed with FLAC 2D models, which were calibrated to account for the three-dimensional effects of ground relaxation by matching the ground convergence of the 2D models with that of the 3D model at locations of key performance indicators (KPIs). The linings were designed for various load combinations with different load factors specified by the MRDC and AASHTO 2012. Since load factors are not typically applied to a geomechanical numerical modeling, the load correction factors, which are the ratio of the load factors and a selected constant, were incorporated into the model. The selected constant was then multiplied with the lining loads at the end of the analysis to obtain the combined design loads for the lining.

The cavern final lining was designed for both the operational design earthquake (ODE) and maximum design earthquake (MDE) specified in the MRDC. The lining was originally analyzed using a simplified pseudo-static method by applying the

FIG.3

SEM cavern typical section.



racking displacements obtained from one-dimensional site analysis on the vertical boundaries of the FLAC 2D model. Since the cavern is a critical and complex structure, its seismic design was required to be checked with a more sophisticated method specified in the MRDC; a dynamic analysis performed with FLAC 2D and three spectra-matching time histories. The interaction between initial and final linings with the presence of a waterproofing membrane was captured by specifying interface properties to bracket the interaction range from slippage to rigid connection. The results from the dynamic analysis indicated that the pseudo-static analysis was adequate for the cavern lining, with some minor rebar modifications to the center wall and plenum slab.

FIG.4

1st Central Station.

1st/Central Station. The 1st/Central Station is connected to the wye structure on the east end and the twin-bored tunnels on the west end. It is a shallow underground station with the depth of invert slab being approximately 14 m (48 ft) below grade and 2.4 m (8 ft) of ground cover over the roof slab. The station houses the trainway, platform and ancillary rooms on the south side. Due to its limited height, the station was designed with no separate concourse level between the platform and plaza, but instead uses a mid-landing for stairs and escalators. The station structure consists of typical 1-m (3-ft) thick exterior walls and invert slab, and a roof slab thickness varying from 0.9 m (2.5 ft) to 1.1-m (4 ft). The station was designed as a typical cut-and-cover structure with applicable loads specified in the MRDC, and AASHTO with Caltrans amendments. The seismic design was done using a simplified pseudo-static method with the racking displacements obtained from one-dimensional site analysis. Figure 4 shows a rendering of the station plaza.

2nd/Broadway Station. The 2nd/Broadway Station is connected to the SEM cavern on the east end and the twin-bored tunnels on the west end. The trainway box is located beneath 2nd Street, and houses the trainway and platform on the first level and the concourse and ancillary rooms on the second level. The trainway box invert is located approximately 26 m (87 ft) below grade with typical 1.2-m (4-ft) thick exterior walls and a 1.5-m (4.5 ft) thick invert and roof slab.

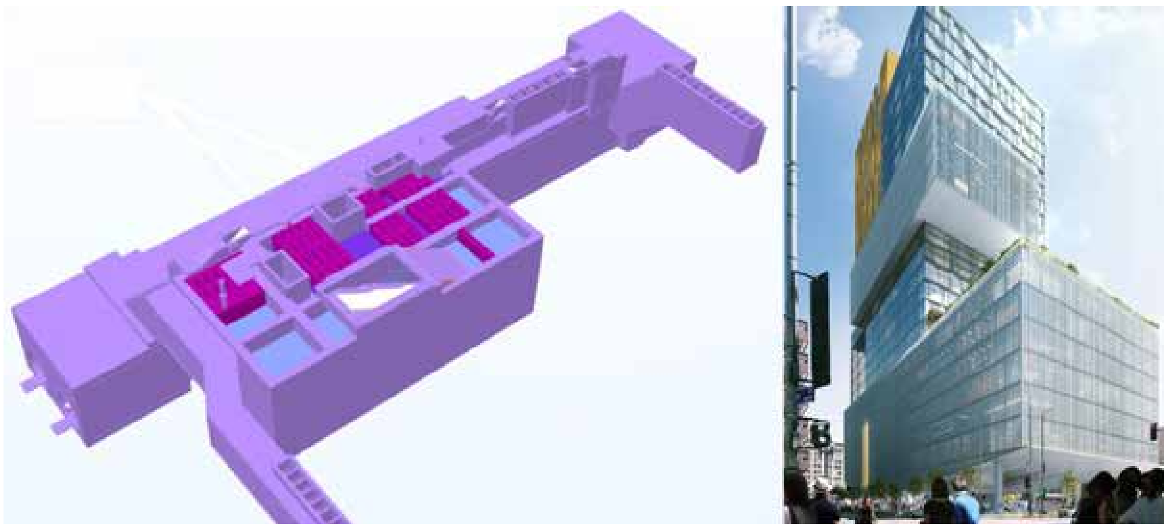
An entrance structure is located on the south side of the station and is located within property owned by a private developer. To resolve right-of-way constraints, a subsurface easement was granted by the developer to Metro - in exchange for the new station entrance structure to also be utilized as a partial foundation for the developer's planned mix-used building of six to 30 stories (i.e., the overbuild). As the deal between Metro and developer went through during the bidding phase, the overbuild loads provided by the developer were included in the bid package as an addendum to be incorporated into the final design. Owing to multiple building concepts under consideration at the time, and to provide flexibility, the overbuild loads were estimated as the envelope loads from each of building concepts. As a result, the overbuild loads ended up being too large and created some constructability issues for the entrance structure. After developing and analyzing several overbuild load reduction alternatives, the entrance structure was ultimately successfully redesigned. The redesign also incorporated a new load transfer system and stem walls extending above the entrance roof, to allow for the future construction of overbuild structural elements with limited impacts to the station operations.

The revised entrance structure typically consists of a 1.9-m (6.5 ft) thick invert slab, 1.2-m (4-ft) thick exterior and interior walls, and a 1.2-m (4-ft) thick roof slab. It is anticipated that the entrance structure and station box will behave very differently during an earthquake event because of the overbuild structure. Therefore, to allow for the anticipated seismic interaction and differential settlement between the two structures, the station box and entrance structure will be separated. The waterproofing system was also carefully designed at this interface to ensure water-tightness.

The structural design of each station structure was carried out with a 3D SAP 2000 structural model. The output from the SAP model was then exported to an Excel macro for detailed design. The seismic design was performed using a simplified pseudo-static racking displacement method. In the 3D model, both the vertical and lateral soil springs were modeled using link elements. The lateral seismic racking displacements along the height of structures were converted into forces that were then applied at the ground ends of link

FIG.5

2nd/Broadway load transfer system and future overbuild.



elements. Figure 5 illustrates the load transfer system in dark pink color to be built on the roof of the entrance structure for the future overbuild.

2nd/Hope Station and Pedestrian Bridge. The 2nd/Hope Station is located adjacent to the Broad Museum and Walt Disney Concert Hall. It is the deepest station of the project with the invert slab located at depth of 32 m (105 ft) below grade. The structural design of this station is similar to the 2nd/Broadway Station, but due to its great depth the vertical transportation of passengers will be accomplished using six high-speed elevators between the concourse and plaza levels. The end wall of the elevator corridor will be decorated with a mosaic tile artwork that will be 18.5 m (61 ft) high by 5.1 m (17 ft) wide.

A pedestrian bridge was also designed to connect the elevated station plaza level with the Broad Museum. A typical concrete structure bridge was originally envisioned and included in the bid. However, per requests from the Broad Museum and City of Los Angeles during design development, the structure type was changed to a high-end pedestrian bridge with glass railings, tree planters, and art lighting to blend in with the surrounding iconic architectural environment. Figure 6 shows a rendering of the station plaza and pedestrian bridge.

Project construction

Tunnels. The bored tunnels were excavated with a refurbished Herrenknecht EPB tunnel boring machine (TBM). The machine was 6.6 m (21.7 ft) in diameter, and was previously used on the Gold Line Eastside Extension project in Los Angeles and the University Link Light Rail project in Seattle, WA. Figure 7 shows the TBM, named Angeli, ready to be launched at the 1st/Central station excavation.

Geologic conditions through the tunneling alignment consisted of approximately 305 m (1,000 linear ft) of alluvium and mixed-face of alluvium and Fernando formation, with the rest of the alignment completely within the Fernando Formation. Prior to the start of tunneling work the TBM was lowered into a launch pit located within the Mangrove site, walked through the street decking excavation underneath the Alameda/1st Street intersection and then prepared for launching at the west end of 1st/Central Station excavation.

The 1st/Central Station tunnel interface and launch points were located immediately adjacent to a three-story parking garage for the Little Tokyo malls, with the tunnels being located about 4.5 m (15 ft) below the garage and outdoor mall building foundations. In an effort to mitigate the potential risks due to tunnel-induced ground movements, the Project installed a compensation grouting system underneath the buildings. A 18-m (60-ft) tunneling demonstration zone was also established within the station footprint to allow for necessary calibration and adjustment of the TBM operations prior to tunneling beneath the garage. A fan of compensation grout pipes up to 122-m (400-ft) long were installed from the station excavation at approximate 1.5 m (5 ft) below building foundations. Prior to the start of tunneling, grout conditioning was completed and made ready for fracturing should building settlement occurred. A horizontal inclinometer was installed approximately 1 m (3 ft) above each tunnel to capture any deep ground movement before it propagated into the building foundations and ground surface. Permeation grout was also installed beneath a large-diameter storm drain along 2nd Street, where the TBM excavated in alluvium at approximately 5.4 m (18 ft) below the pipe.

A comprehensive building protection monitoring program was additionally established using multipoint borehole extensometers (MPBXs), building monitoring points, deep surface settlement points (DSSPs), ground surface settlement points (GSSPs), water levels, tiltmeters and crack gauges on structures along the tunnel alignment, to monitor tunneling-induced ground movements.

FIG.6

2nd/Hope Station and glass railing pedestrian bridge.

The tunnel excavation started from the eastern end of the alignment on Feb. 6, 2017. To allow for installation of compensation grout tubes from within the station excavation, the upper portion of demonstration zone was excavated to provide a working platform underneath the street decking. This resulted in ground cover above the tunnels as shallow as 2.1 m (7 ft). To prevent tunnel blowout under TBM face pressures, the contractor installed surcharge utilizing 1-ton nylon bags filled with soil placed atop the working platform. After some minor mechanical issues and ground heaves within the demonstration zone, the TBM was able to mine beneath the garage and buildings with no measurable settlement observed. Although the compensation grouting system remained in standby mode during tunneling operations, the system never had to be utilized.

A tunneling incident did occur later when the TBM mining the L-track tunnel struck two undocumented steel beams beneath 2nd Street. (It was subsequently determined the beams were likely abandoned in place as part of a previous adjacent construction project.) Despite the strikes though, the TBM was able to cut through and break the steel beams into pieces. Some smaller steel pieces were discharged through the end of screw conveyor. However, larger pieces became stuck inside the cutterhead muck chamber and in front of the cutterhead, which required an intervention to remove the pieces and to repair some damage to the cutter tools.

The No. 2 screw conveyor main shaft cracked shortly after the beam strikes and subsequent restart of mining. The cutterhead and screw conveyor were temporarily repaired and the TBM safely holed-through at the 2nd/Hope Station on June 1, 2017. Some additional repair was required to the machine at the 2nd/Hope Station before it was re-launched for the L-track tunnel reach between 2nd/Hope and Flower Street. Once the TBM completed the L-track tunnel, it was transported back to the 1st/Central Station. The damaged screw conveyor was then replaced with a new one before the TBM was relaunched for the R-track tunnel.

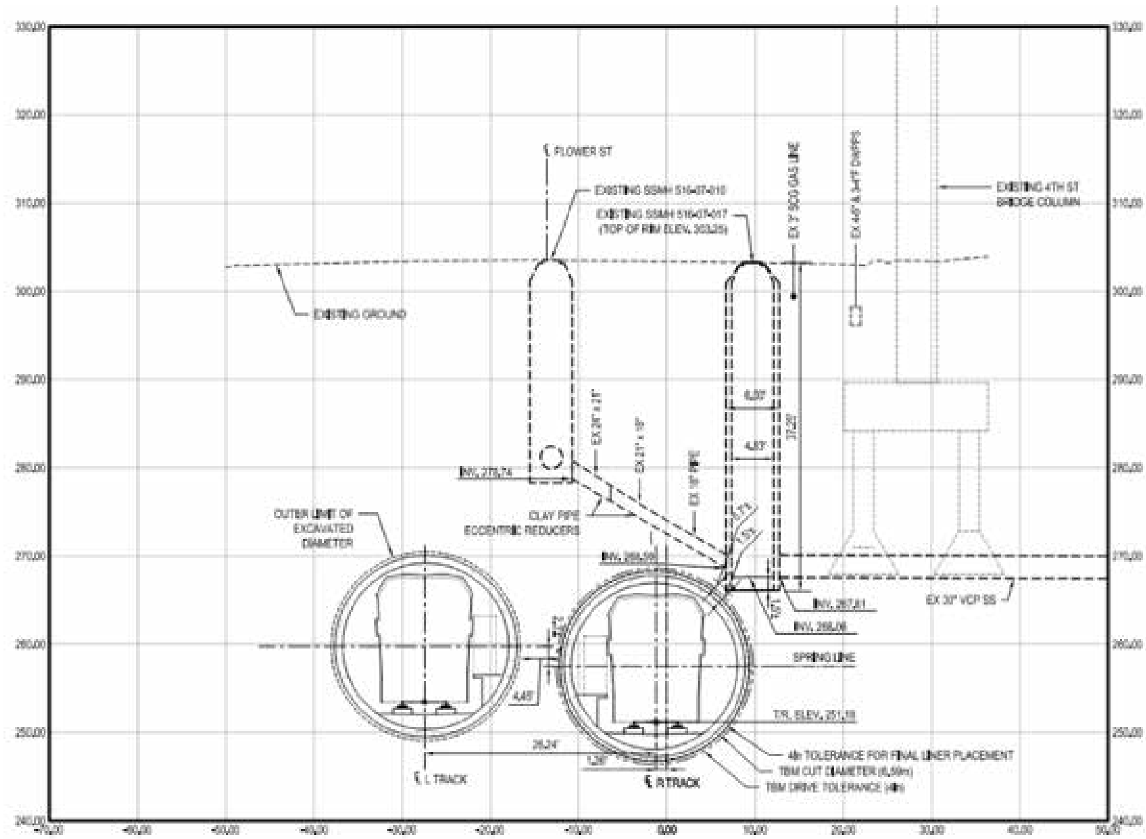
Bored tunneling operations also had to overcome a series of abandoned steel tiebacks along Flower Street between 3rd and 4th Streets. During the preliminary engineering phase, existing tiebacks along the tunnel alignment were identified based on available record drawings. It was determined at the time that some tiebacks from the construction of the Bank of America building were located within the R-track tunnel envelope. A tieback removal pit had to be included in the bid document so that all known interfering tiebacks could be removed prior to the TBM mining through the area. Ultimately, a shaft and adit were designed and constructed by the contractor, and known tiebacks were successfully removed. However, the abandoned tiebacks from the construction of another project on the other side of the street were not accurately documented or recorded.

FIG.7

TBM Angeli at launching shaft.

FIG.8

TBM mining constraints at Flower and 4th Streets.



These tiebacks were struck by the TBM but, similar to the steel beam strikes along 2nd Street, the TBM was able to cut through the steel tiebacks and break most of them into pieces small enough to be discharged through the auger and conveyor. On a few occasions, pieces of tieback rod did become lodged between the auger and conveyor shaft, which required the torch-cutting of an opening in the screw cover to remove the pieces.

Finally, the TBM successfully navigated several constraints along Flower Street below the 4th Street overpass, as shown in Fig. 8. The TBM mined beneath a deep brick manhole and 45 cm (18 in,) sewer pipe, with less than 0.6 m (2 ft) of separation to the pipe and only 0.3 m (1 ft) to the manhole. At the same time, the TBM traveled within a few feet above the battered piles of the 4th Street overpass. Subsequent inspections of the manhole, pipe and overpass found no damage had occurred.

The bored tunnels were successfully completed on Jan. 17, 2018. Even though the TBM experienced some incidents, the tunnel operations were highly successful with little to no ground and building settlements observed. The average advance rate was approximately 21 m (70 ft) per day, with a project tunneling production record of 58 m (190 ft) completed on one day.

Crosspassages. There are three cross passages along the project alignment. Each cross passage is approximately 5.4 m (17.6 ft) in outside diameter and 3 m (10 ft) long, with a cast-in-place reinforced concrete final lining. The crosspassages were excavated using SEM and fiber reinforced shotcrete initial lining. Prior to removal of the PCTL segments to make openings for the cross passages, both tunnels were supported with hamster cages made up of two ring beams connected by a series of tie-beams. The cages were designed to be collapsible and were transported into the tunnels on a rail-running frame. Erection of cages into their designed positions was achieved using hydraulic jacks mounted onto the cage frames. Figure 9 shows a hamster cage positioned with a cross passage opening to the left. All three cross passages were successfully excavated in Fernando formation which provided excellent SEM standup time and minimal ground water inflows.

SEM cavern. The SEM cavern is one of the most critical components of the project and draws a lot of attention from affected stakeholders. Work and action plans were carefully prepared by the contractor and approved by Metro and the City of LA Bureau of Engineering (LABOE) prior to start of SEM work. A canopy of 18 m (60 ft) long grout tubes was installed from the 2nd/Broadway station excavation east headwall. Some grout tubes hit the above-mentioned abandoned steel beams under 2nd Street, and the tubes had to be terminated shorter than planned. A reinforced concrete beam was constructed at the end of canopy pipes, on face of the head wall, to provide stability for the grout pipe canopy.

The SEM excavation was performed following a left drift - right drift - center drift excavation sequence. A CAT 328D LCR excavator with a roadheader attachment was used for the left drift and right drift excavations, while an ITC was used for the center drift. Shotcrete operations were performed using a Potenza robotic sprayer. The excavation started with 1-m (3.4 ft) round length and top heading and bench sequence. Since the PCTL ring length is 1.5 m (5 ft), the construction sequence was a typical three-round cycle that includes rounds A and B to excavate and remove the PCTL ring, and round C to excavate only. A typical excavation of top heading and bench of one round consisted of excavation; removing PCTL segments; installing 5 cm (2 in.) of flashcoat; installing lattice girders channels and wire mesh; installing 12.7 cm (5 in.) of shotcrete to 0.45 m (1.5 ft) from the end of current round; and installing 12.7 cm (5 in.) of shotcrete to complete the previous round. The excavation profile and shotcrete application were scaled with the Amberg system. The Fernando formation presented a very favorable ground condition with an excellent standup time. Prior to the excavation there was a concern about possible connectivity of excavation, with the overlying 3.6 m (12 ft) high by 3 m (10 ft) wide storm drain with weep holes. However, no groundn water flows were observed except for some isolated damp spots on the excavation face.

Due to the significant size and critical nature of the SEM cavern, an extensive monitoring program was implemented in order to measure movements of the ground surface and adjacent buildings. This included convergence arrays inside the excavation measured with the Amberg system, automated MPBX, utility monitoring points (UMP), building monitoring points (BMP) and GSSPs. The BMP's and GSSPs were monitored using total stations. Data from GSSPs were then processed to produce ground surface settlement contour maps and settlement slopes that were then used to check against project specified criteria and to determine if any adjustment to the excavation sequence was necessary. The measured ground movements were found to typically be in line with the predicted values, and no excessive ground movements were recorded.

The SEM cavern was excavated with three eight-hour shifts per day, five days per week. The left drift excavation was started on May 31, 2018 and completed on Oct. 22, 2018. The right drift started on July 5, 2018 and completed on Dec. 6, 2018. The center drift started on Aug. 14, 2018 and was completed on Jan. 25, 2019. Figure 10 shows the excavation of center drift in operation.

1st/Central Station. The 1st/Central Station is the shallowest of the three being constructed, with an invert approximately 13-m (45-ft) below finished grade. The

FIG.9

Crosspassage excavation with hamster cage tunnel support.

FIG.10

SEM cavern center-drift excavation.

FIG.11

Construction of 1st/Central Station invert.

excavated area of this station also served as the launching site for the TBM, for both the left and right tunnels. The support of excavation at this location was constructed mostly from a soldier pile and timber lagging system, with tie backs and 1-m (3-ft) diameter pipe struts. However, at the TBM launch points along the west bulkhead, the SOE was constructed using 20-cm (8-in.) Shotcrete facing supported by six rows of fiberglass soil nails, which allowed the TBM to successfully penetrate the wall. Figure 11 shows the construction of the station invert slab prior to the start of TBM operations.

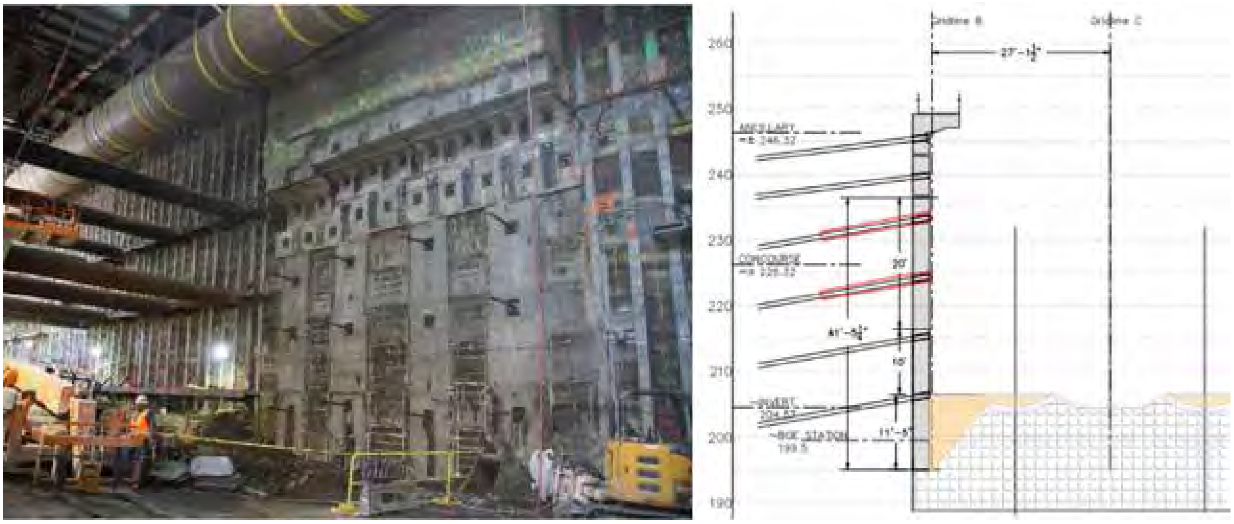
2nd/Broadway Station. With an invert 26 m (85 ft) located below 2nd Street, the 2nd /Broadway Station is the second-deepest of the three stations being constructed. Excavation for the station trackway structure began in August 2016 but was then halted to install a large-diameter Hobas storm sewer, and to allow the TBM to pass beneath both the L-track and R-track tunnels. The decision to have the TBM pass beneath this area rather than walking the TBM through a completed excavation site was made to maintain the overall project schedule.

The soil profile at this station consists of Fernando formation overlain by 4.5 to 9 m (15 to 30 ft) of alluvium material. The TBM mined successfully through the station while the excavation was still more than 9 m (30 ft) above. Once both bored tunnels were mined, portions of the tunnels were then backfilled to the spring-lines with spoil materials to further control convergence, and excavation was resumed. The PCTL rings were then sequentially exposed, cut or unbolted, and transported off site for demolition and disposal. Excavation to the final invert was reached in August 2018.

Immediately adjacent to the north wall of the guideway structure is an historical mid-rise building. This presented a constructability challenge as a portion of the building basement extends southward by more than 1.5 m (4 ft) into the 2nd Street public right-of-way, and is located immediately above the trackway structure excavation. An innovative and complex underpinning system had to be erected consisting of spiling, two rows of precast panels, and a series of cast-in-place columns and timber lagging. The system was constructed in a top-down approach and anchored with tiebacks and 20-cm (8-in.) diameter pipes to

FIG.12

Underpinning of historical LA Times building at 2nd/Broadway.



control vertical movement of the system. Prior to the installation of the unpinning, liquid levels, crack gauges, and monitoring points were affixed to the basement structure. However, no measurable movement or cracking of the basement structure has been observed.Figure 12 includes a photograph of the completed underpinning system a sketch of the final underpinning design.

2nd/Hope Station. With an invert depth exceeding 32 m (105 ft), the 2nd/Hope Station is the deepest of the three stations being constructed under the project. The soil profile at this location consists mostly of Fernando formation overlain by up to 7.6 m (25 ft) of alluvium. Mass excavation work started in March 2016 and was completed in February 2017. More than 7,100 truck loads (99,500 cu yd) were removed and transported to a dump site located 32 km (20 miles) from downtown Los Angeles. A photograph of the completed station excavation is shown in Fig. 13.

FIG.13

2nd and Hope Station excavation.

A soldier pile and timber lagging system with struts and tiebacks was used for the support of excavation. Solder beam sizes ranged from W24 x 76 to W24 x 335 and were typically spaced at 2.1 to 2.4 m (7 to 8 ft) on centers. Due to the upper alluvium layers and noise abatement requirements for the project, solder beams were installed in 91 cm (36 in.) diameter pre-drilled and cased holes, rather than being driven. Struts consisted of 91-cm (36-in.) diameter pipes installed at up to five levels. Tiebacks up to 38 m (125 ft) long and angled at 15 degrees, with 8 to 14 strands each, were installed where struts could not be installed due to constructability constraints. More than 350 tiebacks were installed before the excavation was completed.

Similar to other locations along the project corridor, a comprehensive subsurface monitoring program was established for the site. Although MPBXs were installed near the ends of the station to monitor TBM work, the station monitoring program primarily relied on a system of BMPs, GSSPs, inclinometers, tieback load cells and strain gauges installed on the pipe struts. Settlements and wall movements were then monitored in real time using Insite GPS and web-based communication software. With few exceptions, data obtained from this monitoring system showed that settlements and movements of the ground surface and support of excavation were generally less than or consistent with predicted values.

Summary

The Regional Connector is a large and complex mega-project being constructed through the urban core of Los Angeles. Major elements successfully completed at the halfway point of construction include the TBM-bored tunnels, tunnel cross passages, cut-and-cover street decking, station mass excavations and initial drifts for the SEM cavern. Despite the known challenges of constructing in a congested urban environment, the contractor has been able to keep the project on schedule. This has been achieved through the efforts of a highly experienced team, focused planning, and the development of innovative engineering and construction solutions.

Good geotechnical conditions afforded by the predominate layer of Fernando formation along the corridor has also helped to facilitate construction. The TBM tunneling was able to advance at an average rate of 21 m (70 ft) per day, with 58 m (190 ft) of mining achieved during one particular day – a record for LA Metro. Ground surface settlements so far have generally been less than or equal to what was predicted from the engineering modeling. The good soil conditions have also made it feasible to construct the track crossover cavern using SEM techniques.

While anticipated construction challenges were successfully overcome, some unexpected obstacles did arise. During tunnel boring, the TBM struck two undocumented abandoned steel piles along 2nd Street and several incorrectly documented abandoned steel tiebacks along Flower Street. Despite these strikes, the TBM was able advance with minimal damage to the machine or impact on the construction schedule. The ability to advance past these strikes is a testament to the Herrenknecht TBM equipment and skillful operation.

The project is scheduled to be completed by winter 2021-2022. Although the project team has overcome several challenges to date, other challenges will arise. Among these challenges is the complex system integration and commissioning of the project that will integrate three operating LRT systems together. The continued focus on planning and use of innovative approaches will best position the project team to successfully complete and commission the Regional Connector project. ■

New directors join the UCA Executive Committee

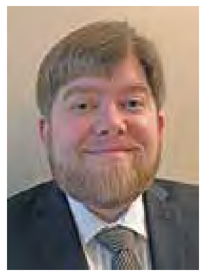
Jon Klug, Matthew Preedy, Robert (Red) Robinson, Tony O'Donnell and Mike Bruen have been elected to serve on the the UCA Executive Committee. Preedy, Robinson and O'Donnell were re-elected to a second term and, along with Klug, will serve until June 2023. Bruen will serve until 2022, since he replaces Alan Campoli, who resigned.

MIKE BRUEN is a vice president with MWH, now a part of Stantec. He has served in various roles including senior project manager, senior tunnel specialist, and engineering geologist specializing in tunnels and underground engineering and construction for wet infrastructure, hydropower and dam projects.

BRUEN

Bruen has more than 35 years of experience working in North America, Central and South America, Asia, and the Middle East. He has been involved in more than 50 tunnel projects, totaling more than 161 km (100 miles) of tunnels with tunnels up to 10 m (33 ft) in diameter, and more than 60 shafts and caverns worldwide. Recently, he was the lead author for the chapter on water tunnels for the UCA of SME book, the History of Tunneling in the United States. He has a bachelor of science degree from the University of New Hampshire and a masters degree from SUNY Buffalo in geology. He is a member of AEG, ITA, the Project Management Institute, the U.S. Society on Dams and the Dispute Resolution Board Foundation.

JON KLUG is the vice-president and part owner of David R. Klug & Associates, a company that provides international and national manufacturer representative services to the underground heavy civil and mine construction industries. He is also vice president and part owner of Klug Construction Systems, a distribution company that services the underground heavy civil and mine construction industries. Klug has a B.S. in civil engineering from the Ohio State University in Columbus, OH. He previously served as quality-control supervisor for CSI Tunnel Systems and for the BWARI project, a segment casting facility in Columbus, OH.



KLUG

Klug has contributed to the UCA of SME through his participation as a member of the SME Online Services Committee, the 2016 World Tunnel Congress Marketing Committee and as a member of the North American Tunneling Conference (NAT) Planning Committee. He has been an exhibitor at NAT and RETC since 2009, compiled and provided the "Tunnel Demand Forecast" for **T&UC**, contributed to the *History of Tunneling in the United States* book and chaired a short course at NAT 2018 on Precast Segment Manufacturing and Design.

ROBERT "RED" ROBINSON is senior vice president of Shannon and Wilson in Seattle, WA. Robinson has more than 40 years of experience on geotechnical assessments and design for more than 400 tunnels throughout Central and North America. He has participated in the design and construction of a variety of tunnels constructed in soil and rock and ranging from 0.9 m (3-ft) diameter directionally drilled utility lines to the world's largest diameter soft ground tunnel at 25.3-m (83-ft) outside diameter for Interstate 90 in Seattle.

ROBINSON

Robinson has published more than 60 technical papers on various aspects of design and construction for tunneling and has been active on several U.S. and international tunneling committees, including RETC, UCA, the Association of Environmental & Engineering Geologists and International Tunneling and Underground Space Asssociation. Currently, he is involved with a variety of transportation and utility tunnels including the (58-ft) excavated diameter Alaskan Way Viaduct replacement tunnel in Seattle; the Regional Connector and Westside Corridor Tranist in Los Angeles, CA; and the Lower and Middle River Des Peres CSO Project in St. Louis, MO.

TONY O'DONNELL, PE, is area manager with Kiewit Infrastructure in Omaha, NE. He has 30 years of engineering experience and has been with Kiewit for 23 years. He has a bachelor of civil engineering with honors and a master of engineering science with honors, both from the University College Cork, Cork, Ireland. He is a member of the Institute of Engineers of Ireland and the American Society of Civil Engineers.

O'DONNELL

At Kiewit, O'Donnell is responsible for the identification, proposal preparation, designer and partner selection, and contract negotiation for all the underground district

(Continued on page 54)

Call for **Nominations**

UCA seeks nominations for the Executive Committee

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

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

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

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

Note for past submissions

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

EXECUTIVE COMMITTEE

(Continued from page 53)

pursuits in North America. In addition, he is currently charged with expanding the Kiewit underground footprint within Canada. His job responsibilities also include direct oversight through the startup phase for all design-build, early-contractor-involvement and nontraditional contracts.

PREEDY

MATTHEW PREEDY, PE, is director of construction management for Sound Transit in Seattle, WA. He has been delivering public works contracts for more than 25 years. While working for the Washington State Department of Transportation, Preedy served as the construction director and deputy administrator for the SR99 Alaskan Way tunnel project in Seattle. Currently, he heads the Construction Management Division of Sound Transit, involved in delivering multiple light rail and commuter rail projects exceeding $65 billion, including the recent planning effort for a new light rail tunnel and stations under downtown Seattle. ■

Personal **News**

The Underground Division of McMillen Jacobs Associates has appointed **ISABELLE LAMB**, LG, as managing director of the Australia-New Zealand Region, based in the Auckland office. Lamb has a geological/geotechnical background and has worked on infrastructure and underground projects throughout the Australia-New Zealand region.

LAMB

She has more than 25 years of experience in the design and management of design teams for the construction of tunnels, underground structures, and associated surface facilities for transit, water/wastewater conveyance and roadway projects. Most recently, she served as tunnel design lead, project manager, and design manager for Sound Transit's University Link Extension, Northgate Link Extension, and East Link Extension E360 projects in Seattle, WA.

The Underground Division of McMillen Jacobs Associates has also appointed **VICTOR ROMERO**, PE, (SME) as executive vice president. He will assist the company president, **DAN ADAMS**, in the management of the Underground Division which has grown to 300 people in 18 offices. Romero has been with McMillen Jacobs for 28 years, providing underground engineering in the water, wastewater, highway and rail transit sectors. For the past eight years, he served as managing director of the Australia-New Zealand Region.

ROMERO

(Continued on page 57)

2019 **Scholarships**

UCA awards scholarships at the 2019 RETC

Every year, the Executive Committee of the UCA of SME awards several scholarships to the most qualified candidates who have applied. In June 2019, three awards were made at the UCA luncheon during the Rapid Excavation and Tunneling Conference (RETC) in Chicago, IL. In addition to the cash awards, winners received travel expenses and free registration to the RETC.

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

All UCA members are asked to promote and disseminate the availability of the scholarship and the application process within their organizations. Any prior experience, such as internships or jobs in the tunneling or underground industry is a benefit to the applicant being considered. The application is available online at www.smenet.org/students/grants-scholarships.

(l-r) Clayton Williams, Tamir Epel and Rajat Gangrade received a UCA scholarship at RETC.

Scholarship recipients

CLAYTON M. WILLIAMS is an undergraduate student at the Colorado School of Mines majoring in civil engieering with a minor in underground construction and tunneling. He has worked as a summer intern for Kiewit in Newburgh, NY on the Rondout bypass tunnel project as assistant TBM shift engineer working on the data analysis of the TBM downtime and scheduling. He also worked for Traylor Brothers in Los Angeles, CA assisting with TBM assembly plans and performing air ventilation and H2S scrubber monitoring and analysis. Currently, he is treasurer of the Underground Construction Association at Mines. He plans to continue his studies to earn a master's degree with the goal of working in tunnel design.

TAMIR EPEL is a graduate student at the Colorado School of Mines (CSM) pursuing a Ph.D. in civil and environmental engineering. He received his B.S. in structural engineering in 2014 from Ben Gurion University, Israel and his master's degree in underground construction and tunnel engineering in May 2019 from CSM. As part of his master's thesis, Epel studied liner load development in the Northgate Link tunnels in Seattle during the main tunnel construction and cross passage construction. He presented the results of the study at the World Tunnel Congress 2018 in Dubai and at the North American Tunneling conference 2018 in Washington D.C. Epel has been a member of the UCA of SME student chapter at CSM for two years and is currently vice president of the chapter. He has also served as a major in the Israeli Army and as a company commander in its reserve forces.

RAJAT GANGRADE is studying for a Ph.D. in underground construction and tunneling at the Colorado School of Mines. He earned his M.S. in civil and environmental engineering at Virginia Tech and a B.Tech in civil and environmental engineering at the Veermata Jijabai Technological Institute, India. Gangrade has worked as a geotechnical engineer 1 for CH2M in Des Moines, IA, where he won two performance awards. He was also a geotechnical engineer 2 for AECOM in India, where he worked on the Mumbai Metro Line 3, a 33.8-km (21-mile) underground metro corridor. Gangrade worked as a research assistant and as a teaching assistant at Virginia Tech and is president of the UCA of SME student chapter at CSM. ■

2019 **Scholarships**

RETC awards scholarships at the 2019 Chicago meeting

The Rapid Excavation and Tunneling Conference (RETC) Executive Committee also awards scholarships to students who wish to develop their skills in the rapid excavation and tunneling field. The committee awarded five scholarships at the June 2019 RETC in Chicago, IL. Each scholar also received a stipend for expenses to attend the conference.

Scholarship recipients

RAHEL DEAN-PELIKAN received a B.S. in mining engineering from the South Dakota School of Mines and Technology and a certificate in engineering management and leadership. She is currently a graduate student at the Colorado School of Mines pursuing an M.S. in underground construction and tunneling with the goal to working as a consultant. She has worked as both a a co-op student and as a summer intern for Lhoist North America for its mining and geology group in Ft. Worth, TX and as a project engineer at its Nelson Quarry, respectively. She also worked in the summer for Freeport-McMoRan in central mine planning.

DEAN-PELIKAN

Dean-Pelikan was a member of the SDSM&T mining and mucking team and was captain in 2018 when it won the world championship in the co-ed division in Cornwall, England. She has also studied at the Western Australian School of Mines.

WEI HU is a Ph.D. student at the Colorado School of Mines pursuing a degree in underground construction and tunneling. His thesis topic is the rheology of conditioned soil for application in soft-ground tunneling by shielded TBM. Hu received an M.S. in geotechnical engineering from Wuhan University, China and worked for the China Geological Survey as a geotechnical engineer. During the school year, he is able to work as a part-time tunnel engineer for Aldea Services in tunnel liner design, TBM face support pressur analysis and underground steel pipe casing design. At CSM, he works as a research assistant in the Earth Mechanics Institute.

HU

JAVAD SHAHMORADI is studying for an M.S. in mineral engineering at the New Mexico Institute of Mining and Technology. He also holds an M.S. in rock mechanics and a B.S. in mining engineering from Amirkabir University of Technology in Iran. He has worked for five years in the tunneling industry in mechanized tunneling and NATM tunneling. At Tara Engineering Co., he was a geotechnical expert on the Sari-West wastwater tunnel and then worked as the superintendent of tunneling on the Qom A-line subway tunnel using EPB TBMs.

SHAHMORADI

CATALINA VANEGAS-PALACIO is studying for an M.S. degree in mineral engineering at New Mexico Tech with a specialization in geotechnical engineering and a focus on underground construction. She received her bachelors' degree in mining and metallurgical engineering, with honors, from the Universidad Nacional de Colombia, where she was vice president of the SME Student Chapter. She has worked as a junior engineer for IRYS, a geotechnical design company in Colombia, on geological surveys, numerical engineering analysis and technical reports for slope stability. She received third place in the 2016 international student poster contest at the 2016 SME Annual Conference in Denver, CO.

VANEGAS-PALACIO

HAOTIAN ZHENG is a Ph.D. candidate in geotechnical engineering at the Colorado School of Mines. His research focuses on back analysis of tunnel construction through computational modeling and field observations. He received an M.S. in civil engineering from Beijing Jiaotong University, China, and performed research on three TBM projects in downtown areas. He earned a B.E. in city underground space engineering from Taiyan University of Technology, China. Zheng interned with Skanska/Traylor Bros. for seven months on its Regional Connector Transit Corridor project in Los Angeles, CA. He worked on on real-time monitoring data analysis and interpretation for Sequential Excavation Method (SEM) cavern construction in downtown Los Angeles and developed a numerical model for SEM cavern excavation. He was also an intern with Highway Consultants, China Communications Construction Co. ■

ZHENG

Attendance **Awards**

RETC and UCA Young Members give attendance awards

The UCA of SME Young Members Scholarship for RETC Attendance provides selected students with an opportunity to attend the RETC Conference and to experience the challenges, opportunities and rewards of a career in the field of tunneling and underground construction. The goals of the scholarship are to increase exposure to career opportunities in the underground industry and to provide educational and networking opportunities to future underground industry professionals.

The 2019 award recipients are:

- Babak Azarfar, University of Nevada Reno.
- Maryam Alahmar, Colorado School of Mines.
- Sebastian Arenas Bermudez, Universidad Nacional de Colombia.
- Ketan Arora, Colorado School of Mines.
- Prosper Ayawah, Missouri University of Science and Technology.
- Miranda Beutler, Missouri University of Science and Technology.
- David Lane Boyd, Colorado School of Mines.
- Awais Muhammad Butt, Colorado School of Mines.
- Jesus Alberto Castillo Gomez, University of Kentucky.
- Carlos Efrain Contreras Inga, Colorado School of Mines.
- Amin Darabnoush Tehrani, University of Texas at Arlington.
- Hector Garcia, Universidad Nacional de Colombia.
- Vinayak Kaushal, University of Texas at Arlington.
- Zahra Kohankar Kouchesfehani, University of Texas at Arlington.
- Hui Lu, Colorado School of Mines.
- Simone Markus, Queen's University.
- Fawad Naseer, University of Alaska.
- Deniz Ranjpour, Tufts University.
- Ramtin Serajiantehrani, University of Texas at Arlington.
- Deepanshu Shirole, Colorado School of Mines,
- Sankhaneel Sinha, Colorado School of Mines.
- Tala Tahernia, Colorado School of Mines.
- Muthu Vinayak Thyagarajan, Colorado School of Mines.
- Andrea Velasquez, Universidad Nacional de Colombia.
- Ashley Wilson, Colorado School of Mines.
- Sana Zafar, Colorado School of Mines.

RETC attendance Award

The RETC Attendance Award is administered by the RETC Executive Committee in conjunction with SME. The goal is to provide students with career and networking opportunities.

Applicants for RETC Attendance Awards must be full-time sophomore, junior, senior or graduate students with a designated major in an applicable field of engineering (civil, mechanical, mining, electrical, geological) or construction/project management.

Each 2019 recipient received RETC conference registration, round-trip airfare to Chicago, IL, hotel accommodations at a conference hotel, conference proceedings and social function tickets. Recipients were responsible for their own ground transportation and for any other expenses, including meals, other than provided by the social functions.

Application forms for RETC scholarships and attendance awards can be found on the SME website at www.smenet.org/scholarships. The application consists of demographic and contact information, school and university information, work history and a few short-answer questions. Up to 12 recipients can be selected.

The 2019 award recipients are:

- Saleh Behbahani, Louisiana Tech University.
- Ravi Chandran Ray, University of Kentucky.
- Anuradha Khetwal, Colorado School of Mines.
- Carolina Navia Vasquez, Universidad Nacional de Colombia.
- Fei Wang, Colorado School of Mines.
- Hongjie Yu, Colorado School of Mines. ■

PERSONAL NEWS

(Continued from page 54)

THOMAS P. O'DWYER, PE, has joined McMillen Jacobs as a principal and tunnel ventilation/fire life safety practice leader based in the New York, NY office.He will be leading tunnel ventilation design and analysis on tunnel design, rehabilitation/upgrade and construction projects. O"Dwyer has 27 years of experience in the design and analysis of transit and road tunnel ventilation systems, tunnel inspection and computational fluid dynamics. He also has extensive experience in computer programming and has been an integral part of efforts to advance and improve the Subway Environment Simulation computer program and other tools used in tunnel ventilation analysis. ■

O'DWYER

DAVID R. YANKOVICH

David R. Yankovich, 66, of Las Vegas, NV, died Jan. 27, 2019.

He was born in Albany, NY on Jan. 15, 1953. He earned a B.S. in civil engineering at Union College, Schenectady, NY in 1981 and an M.S. in civil engineering from Worcester Polytechnic Institute, MA in 2000.


YANKOVICH

Yankovich worked his way through school at a foundry and as a practicing engineer. He was a member of ASCE and the Boston Society of Civil Engineers. He was a licensed professional engineer in CA and NV and a licensed structural engineer in AZ and MA. He worked as a surveyor, as well as a structural engineer, on post-tensioned, precast parking garages.

Yankovich later worked for Sverdrup and Black and Veatch in project engineering and management before joining Parsons in 2008 as a project manager and vice president overseeing water/wastewater tunnel projects.

Yankovich's work as a civil engineer in the United States and overseas encompassed planning, design and construction services for water/wastewater and transportation projects. Some of his major projects included Boston's Big Dig, the Massachusetts Water Resources Authority MetroWest water supply tunnel, the Las Vegas Clean Water Coalition Systems Conveyance and Operations Program, the Los Angeles Phase 1 and 2 Central Outfall sewer rehabilitation, Honolulu's Sand Island gravity sewer and Dubai's Deep Tunnel storm water system.

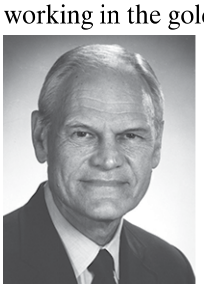
Yankovich also dedicated much of his last 10 years to the design of the Sanitation District of Los Angeles County's new effluent outfall tunnel (Clearwater Project). At a groundbreaking ceremony in May 2019, he was remembered for his commitment to the project, including working until his last days.

Yankovich is survived by his wife, Laurie; his sister, Marylyn; daughter, Sandee; and two grandchildren. ■

RICHARD J. ROBBINS

Richard James Robbins, president and chief executive office of The Robbins Co. from 1958 to 1993, died May 30, 2019 in Seattle, WA. He was 85.

Robbins was born in 1933 in Grass Valley, CA, to James Snowell Robbins and Muriel Ingrid Onsrud Robbins, when his father was a mining engineer working in the gold mining boom. He spent many of his younger years in the wilds of Candle, AK north of the Arctic Circle, where his family lived in remote conditions while mining. Seattle was their home base until he moved to Illinois. He attended Michigan Technological University in the Upper Peninsula of Michigan, his father's alma mater, and received degrees in mechanical, civil and mining engineering. After serving in the U.S. Army, he spent summers mineral prospecting in Alaska for his dad.


ROBBINS

Robbins was widely regarded as a titan of the tunneling industry. He built The Robbins Company into an industry leader, from the first Double Shield machine, to modern-day disc cutters for hard rock, to his notable TBM innovations at the Channel Tunnel connecting the U.K. and France. He filed 11 U.S. patents and 56 foreign patents in the field of underground mechanical excavation and ultimately won the 2009 Benjamin Franklin Medal in Engineering for his contributions. He accomplished all of this after taking over the company at the age of 25, following the untimely death of his father in a plane crash.

Robbins and his wife, Bonnie, lived in a home on Lake Washington for 40 years, where they raised their daughter, Jennifer and son, Jim. He enjoyed many athletic activities throughout his life including running marathons, climbing Mt. Rainier twice, scuba diving, fly fishing and team rowing with the Lake Union Crew, which he joined at age 80. He enjoyed sailboat cruising with his family and friends as well as competitive sailboat racing, including several trans-Pacific races. His other interests included bird watching, wildlife conservation, the Seattle Symphony, Seattle Opera and Seattle Art Museum.

He served on the board of directors or had important roles in many organizations including the Michigan Tech Board of Control, Young Presidents Organization, Washington Fly Fishing Club, Overlake School Parents Club, Washington Trade Association, Washington State Sister Program, United Way of King County and the Virginia Mason Hospital. He and Bonnie were founding members of the Global Partnerships Board.

"In 1968, when I first had the chance to work for what was then known as James S. Robbins Co., I did not fully appreciate that I was getting a chance to work with the greatest innovator in the tunneling industry," said Robbins President Lok Home. "Dick was a great mentor as a boss and as a person. He was always pushing the limits of what could be done with TBMs. Dick's integrity, energy, and passion improved the worldwide tunneling industry, and his creations set many of the industry standards. It has been an honor to further the great name of Robbins in the industry."

Robbins is survived by his wife, Bonnie, his son, Jim and his daughter, Jennifer. ■

Products

Sandvik introduces the DD320S drill


The DD320S drill.

Sandvik Mining and Rock Technology's new drill is a two-boom, hydraulic-controlled development drill engineered to excel in demanding underground conditions, such as tunneling and mining, and various drilling applications. At the heart of the new Sandvik DD320S drill is proven technology that uses THC560 hydraulic drilling controls, a B26XLF boom and a HLX5 rock drill, with 20 kW (26.8 hp) impact power, that ensures long running hours with minimum downtime. It is optimized for 43-64 mm (1.7-2.5 in.) diameter bore holes and 76-127 mm (3-5 in.) reaming holes. Its carrier components, such as the diesel engine and layout, are similar to Sandvik DD321 technologies, ensuring common service principles and spare parts across the whole fleet.

The new drill is available with an optional operator cabin and comes with ergonomic hand rails and anti-slip surface stairs. The platform provides comfortable drilling control and tramming stations (optional), a movement prevention switch and access detector, as well as a new compressor thermal monitoring system.

www.rocktechnology.sandvik

GeoSLAM and Normet enhance quality of sprayed concrete applications

GeoSLAM and Normet have joined efforts in developing technology for mining and tunneling customers to enhance the safety, efficiency and quality of sprayed concrete solutions. Process Monitor Live, which uses advanced LiDAR technology, offers real-time guidance on the thickness of sprayed concrete being applied to the walls and face of a tunnel during ground support operations. Process Monitor Live is now embedded into and available through Normet's SmartScan solution.

Using 3D laser scanning technology, SmartScan eliminates the need for manual calculations using probes and can significantly improve the efficiency and safety of sprayed concrete processes. The operator can automatically calculate and monitor applied sprayed concrete thickness and volumes for enhanced efficiency and less waste. SmartScan uses advanced technology equipped on the machine to remotely scan areas where repairs and concrete application may be needed.

Process Monitor Live has been designed to provide real-time visual intelligence through a simple, user-friendly interface. Manual or automated scans can be carried out and processed to an editable and exportable point cloud in less than five minutes. The results are highly visual, easy to understand and can be exported into common file formats such as .las and .csv for retrospective analysis. It has a repeatability of +/- 5 mm even in difficult atmospheric conditions, such as tunnels and underground mines.

www.normet.com/smartscan

Epiroc launches pumpable resin system for underground rock bolting

One of the more difficult rock reinforcement tasks in tunneling and underground mining is how to install long-term rock bolts in poor rock conditions. Blocky or friable ground often leaves drilled bolt holes blocked or partially blocked. This slows down or prevents the introduction of bonding agents, such as cement grout or resin cartridges, into the bolt hole.


Epiroc's pumpable resin system.

Together with LKAB, Epiroc has developed a solution to this problem. The result is an integrated, pumpable, two-component resin system that can be used with a self-drilling, anchor-style bolt in tougher ground conditions or, alternatively, with a two-step hollow bolt in more moderate ground conditions.

Having the ability to choose a long-term rock bolt that suits the ground conditions means that customers are able to achieve an optimal rock reinforcement regime in terms of function and budget. The integrated pumpable resin system from Epiroc is designed to be used on the mechanized bolting machine models Boltec M and Boltec E. ■

www.epiroc.com

Thank you to the Corporate and Sustaining member companies of UCA of SME for their membership and support in 2019.

Your support of the UCA of SME demonstrates a corporate leadership for advancement in technology, skill and innovation in the industry.

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T&UC Tunnel Demand Forecast

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

T&UC Tunnel Demand Forecast

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

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
W-6: Highway 90 to SW Military Drive	San Antonio Water Systems	San Antanio	TX	Sewer	28,000	10	2020	Under design
D2 Subway - 2nd Light Rail Alignment	Dallas Area Rapid Transit	Dallas	TX	Highway	3,000	22	2020	Under design
I-70 Floyd Hill Highway Tunnel	Colo. Dept. of Transportation	Denver	CO	Highway	15,840	60x20	2022	Under design
Ship Canal Water Quality Project	Seattle Public Utilities	Seattle	WA	CSO	14,250	19	2018	Under design
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	Transit	10,500	18	2022	Under design
L.A. Metro Westside Phase 2 Phase 3	Los Angeles MTA	Los Angeles	CA	Subway	26,500 26,500	20 20	2016 2018	Tutor Perini/O&G JV awarded Frontier-Kemper/Tutor/Perini awarded
Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2020	Under study
Folsom Area Storm Water Improvement	SFPUC	San Francisco	CA	CSO	4,000	12	2022	Under design
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2021	Under design
SVRT BART	Santa Clara Valley Trans Authority	San Jose	CA	Subway	22,700	20	2019	Single tunnel option approved
California Waterfix 1 California Waterfix 2	Delta Conveyance Design and Const.	Sacramento	CA	Water	39,905 403,400	28 40	2020 2020	Delayed Delayed
Newell Creek Dam	City of Santa Cruz	Santa Cruz	CA	Water	1,500	14	2020	Under design
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2018	JayDee/Michels/C&M McNally awarded
Ashbridges Bay Outfall Tunnel	Metrolinx	City of Toronto	ON	CSO	11,500	23	2018	Southland/Astaldi JV Awarded
Yonge St. Extension	Toronto Transit	Toronto	ON	Subway	15,000	18	2016	Under study
Taylor Massey Tunnel	City of Toronto	Toronto	ON	CSO	20,000	18	2018	Under design
Inner Harbour West	City of Toronto	Toronto	ON	CSO	18,400	19	2021	Under design
Scarborough Rapid Transit Extension	Toronto Transit Commission	Toronto	ON	Subway	25,000	18	2018	Under design
REM Transit Tunnel	City of Montreal	Montreal	QC	Subway	27,000	22	2017	SNC/Dragados/Aecon JV Awarded
Green Line LRT	City of Calgary	Calgary	AB	Transit	26,250	20	2018	Prequalifications underway
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Traylor/Aecon JV awarded
Annacis Island Outfall	City of Vancouver	Vancouver	BC	Water	8,000	10	2017	Pomerleau/Bessac Awarded
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	Under design
Broadway Sky train	Trans Link	Vancouver	BC	Subway	25,000	18	18	Under design
Northern Gateway Hoult Tunnel	Enbridge Northern	Kitimat	BC	Oil	23,000	20	2014	Under design

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As far as the east is from the west, so far hath he removed our transgressions from us. Psalm 103:12