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TUNNELING & UNDERGROUND CONSTRUCTION

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Ground freezing

TARP McCook Tunnel

Tunnel demand forecast

Special Editorial Supplement from the publisher of Mining Engineering

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AN OFFICIAL PUBLICATION OF UCA OF SME WWW.SMENET.ORG VOLUME 10 NO 3 SEPTEMBER 2016

COVER STORY

In this issue — Poor ground conditions around the shafts at the Northern Area Purification System was halting a major expansion of the potable water system in Argentina and forced contractors to shift to ground freezing, page 24. The tunnel connection at the TARP McCook Tunnel is discussed on page 34. Cover photo is of the purification system.

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DEPARTMENTS

CHAIRMAN'S COLUMN

Planning continues for another successful year for UCA of SME

In the June 2016 Chairman's Column of *T&UC* I wrote about our very successful World Tunnel Congress (WTC) 2016. Since then, I have continued to hear from member countries about how well the event was received. My thanks again to the entire WTC 2016 team.

The Executive Committee of the UCA has elected four new members to the committee to replace four members whose terms have expired. The new members of the committee are Michael Smithson, Jack Brockway, Richard Redmond and Erika Moonin. My congratulations to them, and also my thanks to the the retiring executive committee members, Greg Hausen, Heather Ivory, Rick Lovat and Kris Murthy, who worked very hard to better our organization. We all appreciate the work they did and their commitment.

Planning for the Cutting Edge Conference to be held in Los Angeles, CA on Nov. 6-9 is continuing and that committee is working very hard to make it a success.

The George A. Fox Conference planning is also ongoing and will be held, as usual, at the Graduate Center of the City Univeristy of New York, in New York City, on Jan. 24, 2017. Let's hope for good weather.

Lastly on the conference front is the RETC event, to be held in San Diego, CA on June 4-7, 2017. All three events should be very educational and rewarding. I am looking forward to seeing as many of you as possible.

The Executive Committee continues with its strong support of the Young Members and the Women Tunnelers groups. The committee urges more of the UCA members to join these groups as they move forward with their agendas and friendships, while we all work together to integrate those members into an overall stronger UCA organization.

In my last column (June, pp. 2), I also mentioned our three strategic goals. Now that the summer is nearing its end, and many of us are returning from vacation or other time off to enjoy the sun, let's get back to the required work ahead of us to attain those goals sooner rather than later.

Lastly, I want to advise that work on the *History of Tunneling* book is nearing completion, and the editors will be sending it for publishing soon. All WTC 2016 attendees will be sent a free copy when the publishing is completed.

Enjoy the remainder of the summer, be safe and begin your preprations and planning for the upcomimg conferences. ■

Artie Silber,
UCA of SME Chairman

Funding plans could put Gateway Project back on track

Amtrak's Gateway plan got a boost in July when the U.S. Department of Transportation announced that it has taken steps to unlock up to $4 billion to help pay for two new Hudson River rail tunnels and a railroad bridge in New Jersey.

The Wall Street Journal reported that federal officials said they are putting the tunnels and bridge on a track that could eventually win grants from a program called New Starts. The tunnel replacement is part of Amtrak's broader Gateway plan, which is projected to cost $24 billion over more than a decade and would be the largest transportation project in the United States.

"This is a huge deal, and it reflects the regional cooperation that's necessary to move forward," U.S. Transportation Secretary Anthony Foxx told *The Wall Street Journal*. "Even a year ago, when I said that the lack of progress on this project was almost criminal, things had been pretty much at a standstill."

The project was cancelled in 2010 by New Jersey Gov. Chris Christie because of a lack of funding. The recent decision by the U.S. Department of Transportation paves the way for a type of funding that would have helped pay for an earlier tunnel project then.

It is the latest step officials have taken in order to show continued progress in a project they argue is critical to avoid crippling passenger-railroad traffic in the Northeast U.S.

Amtrak's current pair of aging tunnels between Manhattan and northern New Jersey are more than a century old, and they sustained flood damage in 2012 from superstorm Sandy.

The project canceled by Christie was set to rely on $3 billion in federal New Starts funding. That project, known as Access to the Region's Core, or ARC, was projected as of

(Continued on page 16)

Norway explores options of a floating tunnel

Norway has hatched an ambitious plan to install the world's first floating underwater tunnels to help travelers easily cross the nation's many fjords. Engineering blog, *Hackaday,* reported that the "submerged floating bridges" would be suspended from pontoons along the surface of the water and connected to trusses to keep the tunnels stable. The floating tunnels would provide another option for travel in the country.

Currently, the only way to travel across the many fjords is by taking a series of ferries – an inconvenient and time-consuming process. The submerged floating bridges would consist of large tubes suspended under 30 m (100 feet) of water, and each one would be wide enough for two lanes of traffic.

Each bridge system would consist of two tunnels, side-by-side, one for traffic in each direction. Despite the unconventional arrangement, officials say it will be much like driving through an ordinary tunnel for commuters. With 1,150 traffic tunnels already in use throughout the country (35 of which are underwater), Norwegians likely won't be too confused by the arrangement.

So why not a normal bridge? Unfortunately, the difficult terrain in these regions makes them unsuited for an ordinary bridge: they're simply too wide and too deep. And at a mile deep, digging a conventional tunnel is unfeasible. One alternative to the submerged bridges might be to build a suspension bridge or a floating bridge over the water, however, these designs have the disadvantage of being susceptible to damage from rough weather. They also run the risk of interfering with Navy ships that sometimes use the water for training.

Norway has so far committed $25 billion in funds to the project, which is expected to reach completion by 2035. There's still some hard work ahead for the engineers involved. Such a system has never been built before, and no one is exactly sure how the wind, waves and water currents in the fjords might affect the structures. If the floating tunnels

(Continued on page 20)

Repairs will close subway line for 18 months

Damage to New York's Canarsie Tube that was sustained during Hurricane Sandy in 2012 could cost as much as $80 million to repair. The repairs will force New York's Metropolitan Transportation Authority to shut down the subway tunnel for 18 months on its L train. That train carries passengers under the East River between Manhattan and Brooklyn, disrupting schedules for as many as 300,000 commuters a day beginning in January 2019.

Bloomberg reported that the decision was forced by damage due to saltwater that flooded the system's Canarsie Tube during Hurricane Sandy in 2012. The tunnel links Manhattan's First Avenue and East 14th Street with Bedford Avenue and North 7th Street in Brooklyn's Williamsburg section. The 24-station line operates between Eighth Avenue in Manhattan's Chelsea east through Brooklyn, terminating at Rockaway Parkway in Canarsie.

The L train is one of New York's busiest subway lines. MTA first announced in January that the tunnel would require extensive repairs. Officials and engineers weighed whether to close it entirely to work on it full time, instead of a one-track, three-year closure. MTA officials said that in visits with local community boards along the line, residents preferred complete, shorter-duration closing.

"Approximately 80 percent of riders will have the same disruptions with either option," said Veronique Hakim, president of New York Transit, which runs the subways for the MTA. "It became clear that the 18-month closure was the best construction option and offered the least amount of pain to customers for the shortest period of time."

"It became clear that the 18-month closure was the best construction option and offered the least amount of pain to customers for the shortest period of time."

Veronique Hakim, President, New York Transit

(Continued on page 18)

Contractors sue Seattle Tunnel Partners for work completed on TBM repair vault

After months of delays on the SR-99 project, the tunnel boring machine (TBM) has now mined 1,036 m (3,400 ft) of the 2,825-m (9,270-ft) tunnel and installed 525 concrete tunnel rings. It seems that troubled project is back on track underground, but above ground, the project continues to face obstacles and one of the latest could eventually play out in a Seattle-area courtroom.

Malcolm Drilling Co, the contractors who built the repair vault that was used to fix the stalled TBM named Bertha, has filed a lawsuit seeking $11 million in extra pay, blaming extreme soil problems and other obstacles in the tricky 2014 job for the additional costs, *The Seattle Times* reported.

Malcolm Drilling Co. created the concrete-lined, 37-m (120-ft) deep access vault and filed the lawsuit this spring against Seattle Tunnel Partners (STP), prime contractors for the future SR-99 tunnel.

The lawsuit adds a few details to a dramatic chapter in the tunnel saga, where crews fended off ground water and sloppy soils to carve a vertical rescue path to reach the damaged tunnel machine.

The vault by itself qualifies as a megaproject, complete with engineering breakthroughs, and now some cost overruns.

The giant TBM had been stalled deep underground next to Seattle's central waterfront since overheating in December 2013. STP hired Malcolm to create the ring-shaped rescue vault — necessary to retrieve the 4-million-lb cutter drive at the machine's front end and allow it to be lifted to the surface. A new bearing, protective seals and some reinforcing steel were installed at street level.

Malcolm, based in San Francisco, asserts in the lawsuit, among other things, that soil conditions were worse than STP represented.

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California WaterFix program enters crucial stage

The proposed California WaterFix project, a $15.5 billion re-engineering of the Sacramento-San Joaquin Delta, is heading into a critical phase over the next year that could well decide if the project comes to fruition.

The Sacramento Bee reported that the state Water Resources Control Board begins months of grueling public hearings on the details of the plan that would include the construction of a pair of massive tunnels beneath the heart of the Delta in Northern California that would help to shore up the reliability of water deliveries to millions of Southern Californians and San Joaquin Valley farmers.

For the project to move forward, Gov. Jerry Brown and other supporters will need to secure a declaration from two U.S. regulatory agencies that the tunnels could operate without violating the Endangered Species Act and the pressure is on to do that before President Barack Obama leaves office next January. Otherwise, the state might have to revisit much of the planning with a new administration in the White House, squandering eight years of work.

"You have certain windows in which you have to get things teed up and completed, and this window is six months," said Jeffrey Kightlinger, general manager of the Metropolitan Water District of Southern California, the Los Angeles agency that relies heavily on Delta water to supply its 19 million customers.

Another key issue looms. Kightlinger said a decision point is fast approaching for south-of-Delta water agencies, which would be responsible for paying for the tunnels, to choose once and for all whether they're on board. The agencies' governing boards need to greenlight the proposal sometime early next year, Kightlinger believes, or momentum will fade on a project that will take at least a decade to complete.

"You need to get these processes started; we need to get going on the design; you need to get going on your geo-technical," Kightlinger said. "You've got a whole huge timeline that's got to be marching along."

Metropolitan hasn't officially committed yet, either. But it has clearly signaled support, including spending $175 million to buy a cluster of Delta islands that Kightlinger said could be used to store construction

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Robbins announces merger plans with Northern Heavy Industries

An agreement between The Robbins Company and Northern Heavy Industries (NHI) Group was finalized on June 28, 2016 in Shenyang, capital of northeast China's Liaoning province.

This initial agreement was the first step of a three-phase merger process and gives NHI minority interest in The Robbins Company. The second phase occurred in July 2016 when NHI assumed 61 percent ownership of The Robbins Company. Lok Home, president of The Robbins Company, will remain vested in the company and continue in his leadership role. In the final phase, The Robbins Company, NFM Technologies of France and NHI will be merged, combining their collective resources and expertise. It is anticipated that Lok Home will assume the role of president of the newly formed company. Operations of The Robbins Company are expected to remain the same.

"This merger puts Robbins in an excellent position to expand our presence in the global tunnel boring machine market," said Home. "It will enable us to provide better global service and support to our customers, and will open the door to new opportunities, especially in China. NHI has very impressive capabilities. Joining forces with them gives us expanded resources to go after more projects and strengthens our reputation as a world leader in the tunnel boring industry."

"By laying out developing plans in Asia, America and Europe, and making a concerted effort together, we will strengthen our competitiveness in the market," said Yang Tao, general manager of the Tunneling Machine Co, a subsidiary of NHI.

Based in Shenyang, NHI employs 10,000 people and is among China's top three heavy machinery manufacturers. Its products are sold to more than 30 countries worldwide. In 2007 NHI merged with NFM Technologies of France, making it a transnational company. ■

Gateway Project: Once shelved project could start up again

(Continued from page 4)

April 2010 to cost $8.7 billion.

Martin Robins, who at one point managed the earlier tunnel project, said initial New Starts approval for ARC "definitely gave it a push forward."

Early estimates peg the price of the tunnels at about $8 billion and the bridge at $1 billion to $2 billion.

The entire Gateway Project is expected to cost $24 billion and will include four major components. The Hudson River tunnels are projected to cost $7.7 billion and begin construction in 2019. The $1.3 billion Portal Bridge North is expected to start in 2017 and the New York Penn Station expansion and the Portal Bridge South are expected to start in 2024 at costs of $5.9 billion and $2 billion, respectively.

Officials warn that the repairs might require shutting the existing tunnels for more than a year, choking a busy route used by the national passenger railroad and NJ Transit commuter trains.

Many major decisions loom, and a number of funding questions have yet to be answered. Officials have yet to formally create a development corporation that would be an affiliate of the Port Authority of New York and New Jersey, which is taking a leading role in the project.

The federal government's decision doesn't award money to construct the projects. But officials said the tunnels and the Portal Bridge North — one of two railroad bridges that would replace an aging, unreliable swing bridge over the Hackensack River — have entered the project-development phase of the funding process. That step is required before construction grants would be awarded.

The existing Portal Bridge's occasional failure to close has long been a source of train delays and is among the examples of Amtrak's aging equipment and structures. ■

Repairs: Damage from Hurricane Sandy to be fixed while tunnel is closed

(Continued from page 8)

Saltwater damage from Sandy caused corrosion to the tunnel's walls, tracks and signal cables, one of nine tunnels to be flooded during the storm. Repair costs have been estimated as high as $800 million. Design and construction plans must begin this year to take advantage of hundreds of millions of federal dollars in financing for the project, the agency said in a news release.

To ensure that the repairs are made in less than 18 months, the MTA will offer incentives to contractors to make good time and punish them for missing target dates.

The New York Post reported that MTA boss Tom Prendergast said the agency will give bonus cash to contractors for shaving months off the extensive repairs needed for the heavily-damaged Canarsie Tunnel.

"We are going to do everything we can to incentivize contractors in this process to get it done faster, in balance also with penalties if they take longer than 18 months," he said at a monthly board meeting.

"There will be pressure to do it in less than 18 months. We want to minimize this impact."

The shutdown of the link between Bedford Avenue in Williamsburg and 1st Avenue in Manhattan is slated to begin in January 2019.

Contractors will likely show up with fresh eyes and see steps they can take to cut the timeline down to less than a year and a half, said Prendergast.

"We've found we've been fairly successful, when we bring people to the table who know a lot of our system and they do a lot of work here, they think up better ways to do it, in manners and methods and means," he said.

Prendergast said the penalties for going past the 18 months will be written into whatever agreements the MTA signs with contractors.

He and other MTA officials did not elaborate on what the exact bonus rewards and specific punishments would be. ■


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Norway: $25 billion has been committed

(Continued from page 6)

prove too difficult, politicians have the right to select a different project to receive the funding.

One option could be a floating bridge similar to the one that was completed in Seattle, WA that was completed in April, 2016.

Seattle's Lake Washington is so deep that support towers for a conventional suspension bridge would need to be nearly as tall as the Space Needle. As a result, engineers opted to build the world's longest floating bridge — and it was just completed this month.

At 2,330 m (7,710 ft), the SR 520 tops its predecessor by about 40 m (130 ft). The old bridge, which opened in 1963, will likely be torn down later this year. Transportation officials say that most of the bridge's materials will be either recycled or reused.

The bridge is equipped with over double the number of pontoons, and is engineered to be more resistant to waves, earthquakes, and winds up to 143 km/h (89 mph). The SR 520 is wider, includes carpool lanes in each direction, and it could also be modified to include a light rail in the future. It's built to last for at least 75 years, but construction director Dave Becher said it could last "indefinitely" if properly constructed. ■

2016 Cutting Edge Conference

Nov. 6-9, Los Angeles, CA

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Seattle: Dispute centers on soil conditions

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STP project manager Chris Dixon said that Malcolm knew about poor ground conditions because the firm previously built a wall of pillars next to the Alaskan Way Viaduct to protect the road from vibrations or sinkholes.

The STP-Malcolm contract started at $932,477, to shoot concrete grout next to Bertha to form an underground wall that would resist ground water. Dixon says the contract started low because STP thought about opening bigger parts of the ring project to bidding before choosing to stay with Malcolm.

Engineering was taking place at the same time, by Denver-based Brierley Associates, for a vault 37-m (120-ft) deep with an inside diameter of 18 m (60 ft). By the time the vault was fully designed, STP and Malcolm agreed on a total of $18.9 million to cover the full costs.

Malcolm drilled down into the soil with hollow tools, filled those spaces with concrete and positioned 70 of those pillars to form a ring. Dirt was scooped out from the circle, gradually descending. Work proceeded during two shifts a day.

Many obstacles slowed the job, according to the lawsuit in King County Superior Court:

- A layer of shells, left by 19th-century settlers, caused the state to halt work for a few days for archaeological study.
- Shallow utility lines near the vault needed to be moved.
- There were voids in the weak fill soil near the surface, adding safety hazards, Malcolm says. STP ordered rocks to be poured into the gaps, which Malcolm says made it more difficult to accurately set the columns.
- Ground water flows and pressures were greater than expected, creating a need for extra pumping.
- The Alaskan Way Viaduct and some streets in Pioneer Square sank (more than an inch, according to state measurements), causing temporary delays and extra ground water monitoring. The roadways reverted to normal, months later.

Finally, some of the new vault pillars were out of plumb, and groundwater seeped in. Excavation was suspended until grout could be added to fill the unexpected small gaps and add compressive strength to

California: Tunnel proponents push for a decision

(Continued from page 12)

materials as the tunnels get built.

Other water agencies have been more lukewarm, citing uncertainties about how much water the tunnels could deliver.

Brown says the project would improve California's water situation significantly. According to the administration, it would enable the State Water Project and the U.S. government's Central Valley Project, operators of the giant Delta pumping stations near Tracy, to ship water to the San Joaquin Valley and Southern California with far fewer interruptions.

The governor's rationale centers on the complexities of the Delta's plumbing system. The existing pumping setup causes crucial river channels in the estuary to flow backward at times. This reverse flow confuses migrating fish, causing them to swim with the currents toward the pump intakes and predatory fish. Decades of pumping have degraded native fish populations and contributed to other woes, sometimes prompting environmental agencies to order a slowdown in pumping operations.

California WaterFix, as Brown's project is officially known, calls for diverting a portion of the Sacramento River's flow via new gravity-fed intakes more than 48 km (30 miles) upstream. The water would be piped to the Tracy pumps via two 12-m (40-ft) wide tunnels. This would eliminate much of the reverse flow problem, the state says, allowing the pumps to operate more reliably while doing less harm to fish.

The state water board hearings will represent a public trial of sorts, exploring impacts on water quality and other issues. Brown's administration and the Bureau of Reclamation will have to defend themselves against claims that the tunnels would further harm the Delta and bring more ruin to its dwindling fish populations.

Separately, California voters in November will be presented with a ballot initiative that could effectively torpedo the tunnels plan. Proposition 53 would require a statewide vote on any public works project financed with at least $2 billion in revenue bonds. The water agencies funding the tunnels would have to borrow far more than that to finance WaterFix. ■

Tunneling completed on Honolulu sewer project

Tunneling on the Kaneohe-Kailua gravity sewer has been completed. The project is the largest sewer project in Honolulu, HI, and it will convey waste water flows from Kaneohe to Kailua while providing wastewater storage to help prevent overflows and spills, especially during storms.

The 5 km (3-mile) route linking the Kaneohe Wastewater Pre-Treatment Facility (KWWPTF) to the Kailua Regional Wastewater Treatment Plant (KWWTP) took 13 months to bore through.

Tunnel construction was primarily staged from the Kailua Regional WWTP and involved the use of a tunnel boring machine (TBM) to drill a tunnel up to about 4 m (13 ft) in diameter. An approximately 3-m (10-ft) inside diameter pipe will be installed in the tunnel to handle waste water flows. The access and retrieval points for the TBM were at vertical shafts at either end of the tunnel. The shaft at the Kaneohe WWPTF will also be used for constructing the Kaneohe diversion structure that will intercept sewage lines; the shaft at the Kailua Regional WWTP will be used for construction of the tunnel influent pump station.

Since the finished tunnel will convey waste water by gravity flow, it slopes from a depth of approximately 12 m (39 ft) below ground level at the Kaneohe WWPTF down toward the Kailua Regional WWTP, ending at approximately 23 m (77 ft) below ground level. A new Tunnel Influent Pump Station (TIPS) will be constructed.

"It's a plus, not only for the island of Oahu, but for the whole State of Hawaii, only because we need to keep the water clean. We need to coral good. We need to keep the fish," Don Painter with contractor Southland Mole JV told *KHON 2 News*.

"Despite this being the largest sewer project in state history, this critical infrastructure project has had very little impact on our residents while ensuring our public and environmental health and safety for generations to come," said Honolulu Mayor Kirk Caldwell.

Phase two of the project is installation of a tunnel influent pump station in the Kailua shaft. TIPS will receive and pump the tunnel flows up to the KWWPTF.

The third and final phase of the project is construction of a tunnel influent facility at the KWWPTF.

Upon completion of all phases, the existing force main that transports wastewater from Kaneohe to Kailua will be decommissioned and the flows are expected to be redirected to the new gravity sewer tunnel in 2018. ■

FEATURE ARTICLE

Ground freezing to repair leaks in slurry wall shaft

The Sistema de Potabilización Área Norte project (Northern Area Purification System) was a major expansion of the potable water system in Buenos Aires Province, Argentina. The aim of the project was to transport and purify raw water from the Paraná River to provide potable water for five communities in the northern part of the province, benefitting up to two million people. The project was constructed by a joint venture (JV) of four South American contractors and consisted of the following key components:

- **Treatment plant:** A 16-ha (39-acre) area was cleared for the construction of a treatment plant to purify 900,000 m^3/day (1.2 million cu ft/d) of raw water from the Paraná River and distribute it to the surrounding communities.
- **Bored tunnel:** Nearly 15 km (9 miles) of 3.6 m (12 ft) inner diameter tunnel, ranging from 18 to 22 m (59 ft to 72 ft) below grade, was bored with two earth pressure balance (EPB) tunnel boring machines (TBM) to draw the raw water from the river. The TBMs started from a central launch shaft and proceeded in opposite directions. Cristina advanced northbound to the Paraná River Intake System, and Liliana advanced southbound to the new treatment plant.
- **Access and ventilation shafts:** Five access shafts and eight ventilation shafts were installed along the length of the tunnel. The access shafts were designed to provide entry points for inspection and maintenance of the final tunnel. The five shafts consisted of one central launch shaft in the middle of the tunnel alignment, one retrieval shaft at each end of the tunnel (intake and treatment plant, respectively) and two intermediate shafts. The intermediate shafts were installed before the TBM passed, with a final liner to be installed afterward.

Shawn P. Coughlin, Juan Leonardo Tello del Pino and Michael A. Schimmenti

Shawn P. Coughlin, member UCA of SME, and **Michael A. Schimmenti** are project manager and project engineer Moretrench American Corp. and **Juan Leonardo Tello del Pino,** member UCA of SME, is engineering manager, Odebrecht Infraestructura email scoughlin@moretrench.com.

Ground freezing loops used at the Sistema de Potabilización Área Norte project.

Access Shaft 3, the intermediate shaft located between the launch shaft and the treatment plant, experienced persistent leaks during initial excavation attempts.

Access shaft 3

The soil near access shaft 3 (Cámara de Acceso 3, or CA3) generally consisted of soft to medium sandy silts and clays from EL +14.5 m to EL -13 m, underlain by very dense sand to EL -34 m. A hard clay layer was encountered beneath EL -34 m. Ground water was encountered at EL +13.2 m (1 to 1.5 m or 3.3 to 5 ft below grade).

The temporary liner for CA3 was comprised of

0.8-m (2.7-ft) thick by 2.5-m (8.2-ft) long by 29.7-m (97.5-ft) deep steel-reinforced slurry panels that formed a 10.8-m (35.5-ft) interior diameter structure (Fig. 1). Waterstops were not used between the panels. A bottom seal of jet grout columns, each 3.5-m (11.5-ft) tall with a nominal diameter of 1.2 m (4 ft), was designed to provide base stability by resisting hydrostatic forces due to the high water table. Jet grouted blocks measuring 10-m (32.9-ft) high by 10-m (32.9-ft) wide by 5-m (16.5-ft) thick were formed using 1.2-m (4-ft) diameter columns around the tunnel break-in and break-out areas to provide stabilization for TBM passage.

Initial excavation began in October 2012 and proceeded without incident for the first week. At a depth of 10.5 m (34.5 ft), there was an inflow of water at a joint between wall panels. The leak increased rapidly and began to carry soil into the shaft, so the JV flooded the shaft to equalize the internal and external pressures and reduce further inflows until the situation could be assessed.

Over the next four months, the JV attempted several different methods to repair the leak: tremie grouting, tube-a-manchette grouting and jet grouting behind known leak locations; jet grouting around the entire exterior perimeter of the shaft; dewatering with deep wells to reduce hydrostatic pressure; and using divers to place formwork and inject grout from inside the flooded shaft. Each effort was unsuccessful, and the JV had to flood the shaft several more times as new leaks were encountered in seven different joints at a range of heights from EL +2.5 m to EL -8.5 m. The volume of leaks was not measured with close accuracy, but in January 2013 the water carried such a volume of soil that it accumulated to a depth of 2.4 m (8 ft) in the shaft over the course of the night.

By early 2013, progress of the southbound TBM Liliana was severely hampered by the delays at CA3. In February, the JV tremie-poured concrete into the shaft to the level of the tunnel invert, then used an excavator with a hydraulic breaker to create openings in the slurry wall for the TBM break-in and break-out. The jet-grouted blocks behind the openings provided isolation from the surrounding soil. The leaks persisted and precluded the construction of the final cast-in-place liner, but a series of trenches and sumps at the base of the shaft controlled the water sufficiently to allow demolition work to proceed.

When the openings were complete, the JV backfilled the shaft to approximately 7.2 m (23.7 ft) above the tunnel crown (two times the tunnel diameter) in order to allow tunneling to continue. After the TBM passed, the

FIG. 1

Shaft section and plan showing soil strata and construction details.

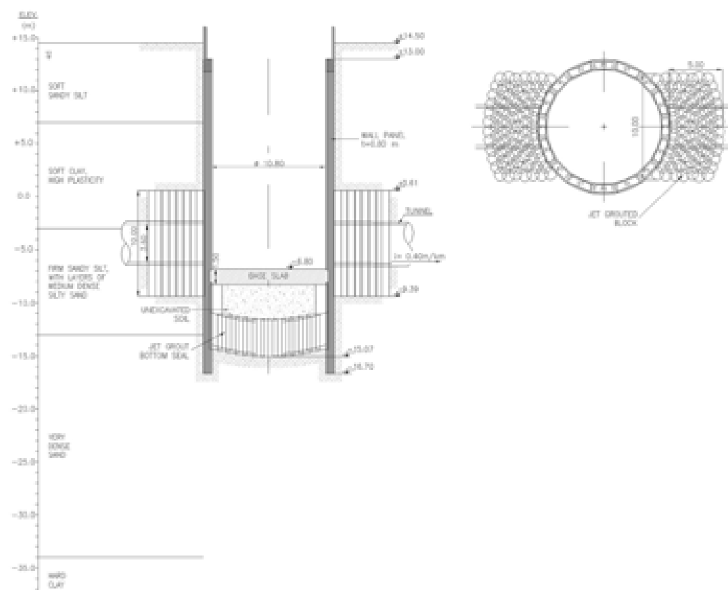
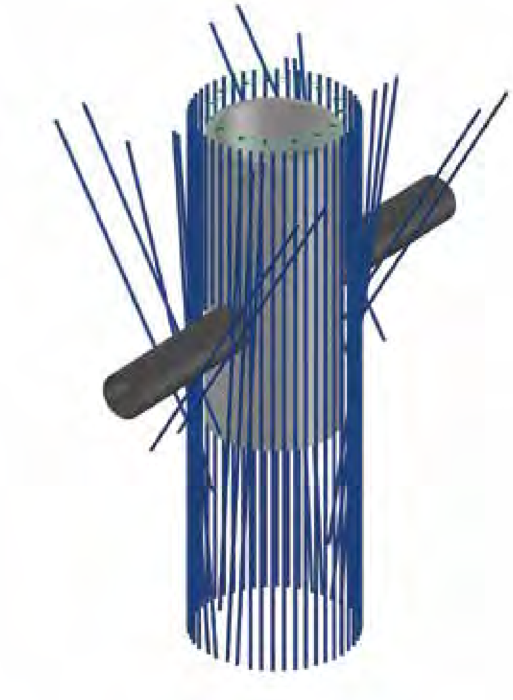


FIG. 2

Proposed freeze pipe layout.



JV contacted a specialty geotechnical subcontractor to provide a solution for the shaft's persistent leaks.

Ground freezing design and installation

The geotechnical subcontractor proposed the use of artificial ground freezing — the extraction of heat from the ground until the pore water in the soil freezes. This technique creates an impermeable, rigid mass of in situ frozen soil.

To chill the soil, metal freeze pipes are installed in the ground at regular spacing. Calcium chloride brine, chilled by mobile refrigeration plants, is circulated through the pipes. The warm soil transfers heat to the cold brine, and the soil is cooled incrementally.

Proposed layout. The system required an array of freeze pipes to freeze the soil around the shaft and isolate the shaft interior from the ground water to cut off the source of the leaks. The frozen wall was designed to provide an independent water cutoff (the slurry wall and jet grouted base were disregarded). The preliminary design called for 68 freeze pipes: 48 vertical pipes at 1 m (3.3 ft) spacing placed 1 m (3.3 ft) outside the exterior perimeter of the shaft and 20 angled pipes to cradle underneath

FIG. 3

As-built Temp/W model contour plot with CA3 slurry wall superimposed. Temperature monitoring pipes are identified as TM-#.

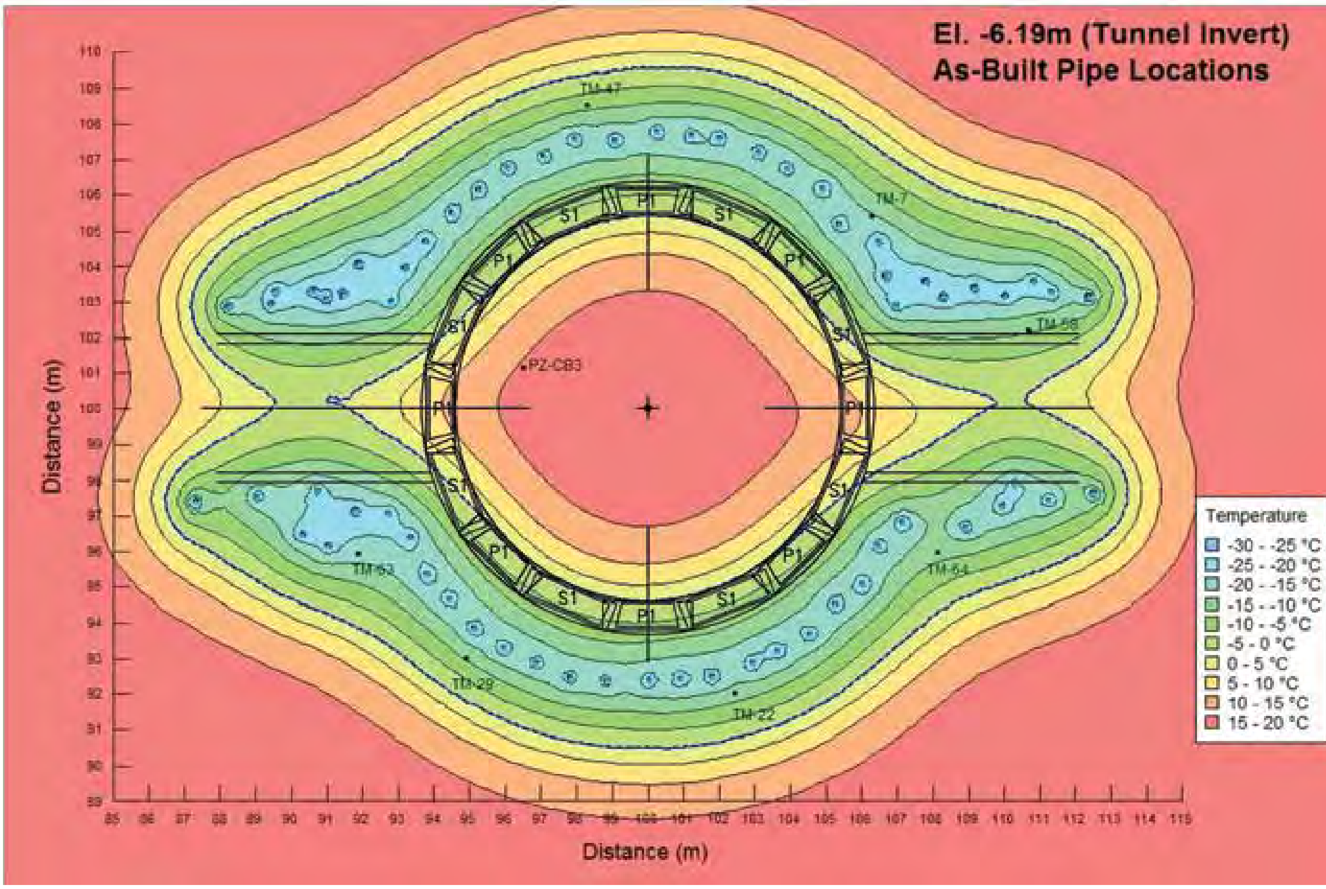


FIG. 4

Aerial view of the ground freezing system.

the tunnel on either side of the shaft. The 10 vertical pipes above the break-in and break-out locations were installed to the top of the tunnel, approximately 18 m (59 ft) deep. The other 38 vertical pipes were installed approximately 55 m (189 ft) deep, extending several meters into the hard clay layer below EL -34 m. The clay provided an impermeable stratum at the bottom of the frozen cylinder to prevent water recharge from below. Additional pipes for temperature monitors and piezometers were also installed to provide data on soil temperature and groundwater levels. Figure 2 shows a rendering of the proposed freeze pipe layout.

In addition to surface pipes, two circuits of contact cooling tubes were proposed for inside the tunnel. These tubes were mounted onto the surface of the concrete liner to chill the concrete on either side of the shaft. They were intended to prevent the warm tunnel from supplying heat to the ground freezing system.

Structural design. The structural engineers were concerned about the stresses on the shaft and tunnel due to the volumetric expansion of frozen soil. Plaxis 3D was used to determine that the additional pressure on the shaft wall and the tunnel could be as high as 520 kPa, with the largest stresses at the intersection of the tunnel and shaft.

With this data, the structural engineers designed concrete rings to reinforce the tunnel liner. Two 25-cm (9.8 in.) thick rings extended 4.5 m (15 ft) in each direction out from the exterior of the shaft walls, roughly corresponding to the area encompassed by the jet-grouted blocks. The rings were intended for temporary use and later removal, but were eventually left in place due to the need for structural support during ground thaw.

The engineers also designed masonry plug walls to be installed upstream and downstream of the shaft to protect the tunnel in case of shaft failure.

Thermal design. To estimate the refrigeration energy and time required to form the proposed frozen wall, the ground freezing subcontrator performed a thermal design using the finite-element analysis program Temp/W. Because the wall was needed only for water cutoff and not for direct earth support, the target soil temperatures were not as stringent as for a conventional structural frozen wall.

The soil parameters for the thermal design were based on the sandy silt layer, assumed to be the least conducive to freezing. Additionally, the freeze pipe layout was modeled at the area of greatest concern: the tunnel invert elevation, where the distance between angled freeze pipes was largest. The design locations of the pipes were used initially. The analysis was repeated using as-built freeze pipe locations after installation. Figure 3 shows the thermal contour plot of the as-built Temp/W model.

The thermal analysis suggested that closure of the frozen wall would be achieved after approximately 63 days of freezing. The final portions of the frozen wall to close would be the areas immediately below the tunnel invert. The area of frozen soil is represented within the dashed blue contour indicating the 0° C (32° F) isotherm.

System installation

Freeze pipes and temperature monitors were installed by rotary drilling methods with a track-mounted core drill using bentonite mud as a drilling fluid. Once the holes were drilled to final depth, 114.3 mm (4.5 in.) diameter steel pipe was inserted into the borehole in 12 m (39 ft) sections and butt welded. An end cap was welded to the first segment in the ground. After installation, each pipe was pressure-tested to 150 percent of working pressure to ensure brine would not leak into the surrounding ground. The pipes were surveyed with an inclinometer to determine deviation from design; due to drilling tolerances, 73 pipes were installed rather than the design quantity of 68 pipes.

After drilling was completed, the brine circulation system was installed. The system consisted of the following components:

- Refrigeration plants: Two mobile plants one 400 hp (298 kW), one 300 hp (223 kW) chilled the brine to a temperature of -25° to -30°C

FIG. 5

Elevation vs. temperature.

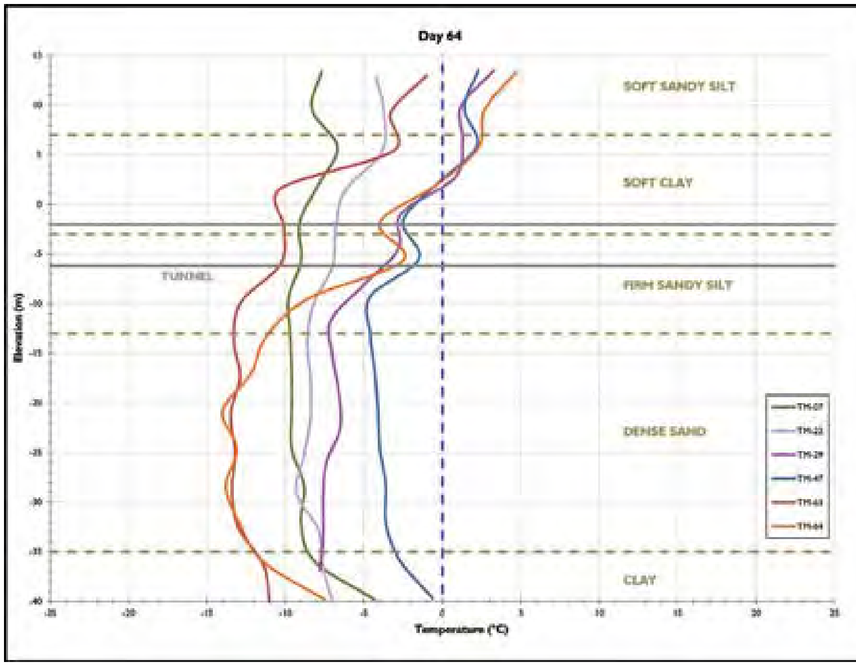
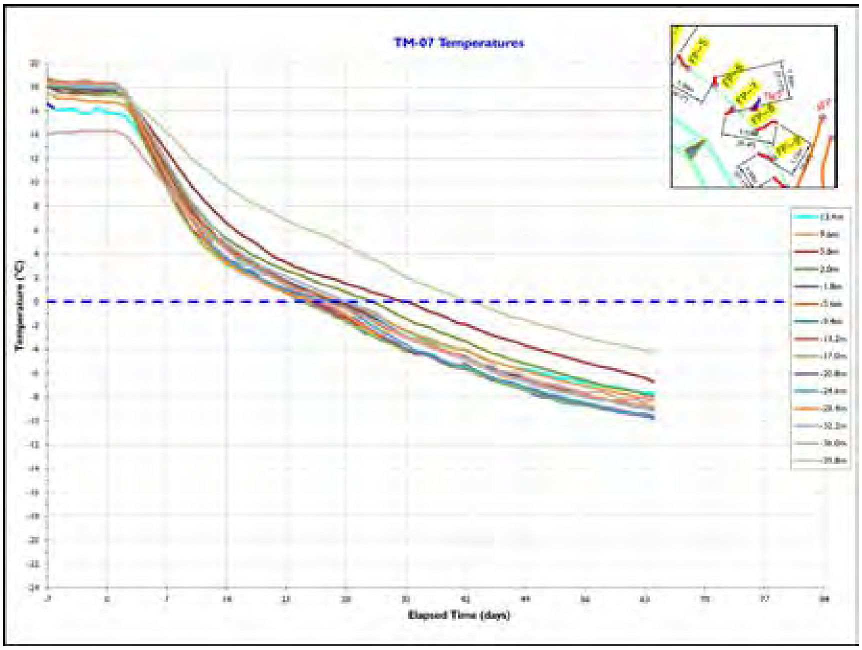


FIG. 6

Temperature vs time in TM-07.



(13° to 22° F). Due to the incompatibility of American motors with the Argentine power grid, electric power was supplied by diesel generators.

- Centrifugal pumps: Two 50-hp (37-kW) pumps, connected in parallel, circulated brine through the piping and plants.
- Header piping: Insulated steel supply and return piping delivered brine through each freeze pipe and back to the plants.
- Drop tubes: Polyethylene tubes were inserted to the bottom of each pipe. Brine flowed down each tube and returned through the annular space between the tube and the steel freeze pipe.
- Tunnel cooling circuits: Rectangular steel tubes were mounted directly on the tunnel liner rings. A pipe was drilled through the top of the tunnel from the interior of the shaft to connect the circuits to brine supply and return piping.

Figure 4 shows an aerial view of the system layout. Two rings of black insulated header piping surround the shaft. One ring supplies cold brine to the freeze pipes, the other returns warmer brine to the refrigeration plants.

Instrumentation

An instrumentation and data acquisition system was installed to monitor the ground freezing progress. The system included sensors for brine flow, temperature and pressure; ambient temperature; soil temperature and piezometer level.

Temperature monitoring pipes were installed around the shaft at varying distances from the frozen wall. A sensor string was installed in each monitoring pipe, with sensors spaced equally from the bottom to the top of the frozen wall.

The sensors were connected to a centrally located control panel and desktop computer for real-time monitoring and data logging. The instrumentation system was activated one week prior to the start of freezing to gather baseline data for comparative purposes.

System operation

From Sept. 10, 2014 until Feb. 4, 2015, the plants operated 24 hours per day to freeze the soil around access shaft 3.

Progress of the frozen wall growth was monitored through daily analysis of the temperature data. The plots in Figs 5, 6 and 7 are each shown 64 days after freezing commenced. The soil cooled at different rates according to the following variables:

- Soil type: As seen in Fig. 5, sensors in the granular soil cooled more quickly than those in fine-grained silt and clay layers. Because silica and quartz have much lower heat capacities than water, soil with higher water content takes longer to freeze.
- Freezing time: Figure 6 demonstrates a typical trend of temperature versus time. The soil cooled rapidly at the outset, then slowed as it approached the phase change from liquid water to ice.
- Distance from the freeze pipes: Sensors closer to freeze pipes cooled more quickly. By plotting temperature versus the distance between from sensor to the nearest freeze pipe, as in Fig. 7, the thickness of the frozen wall can be approximated. On Day 64, all sensors within 1.1 m (3.7 ft) of a freeze pipe were below 0°C (32° F), implying that the frozen wall was roughly 2.2-m (7.2-ft) thick by that date.

The data suggested that the frozen soil had fully formed into a watertight wall by Day 64. Closure of a frozen shaft is normally indicated by a rise in water elevation inside the shaft. Since CA3 had an existing concrete structure that affected ground water response, it was more difficult to determine

FIG. 7

Temperature vs. distance to nearest freeze pipe.

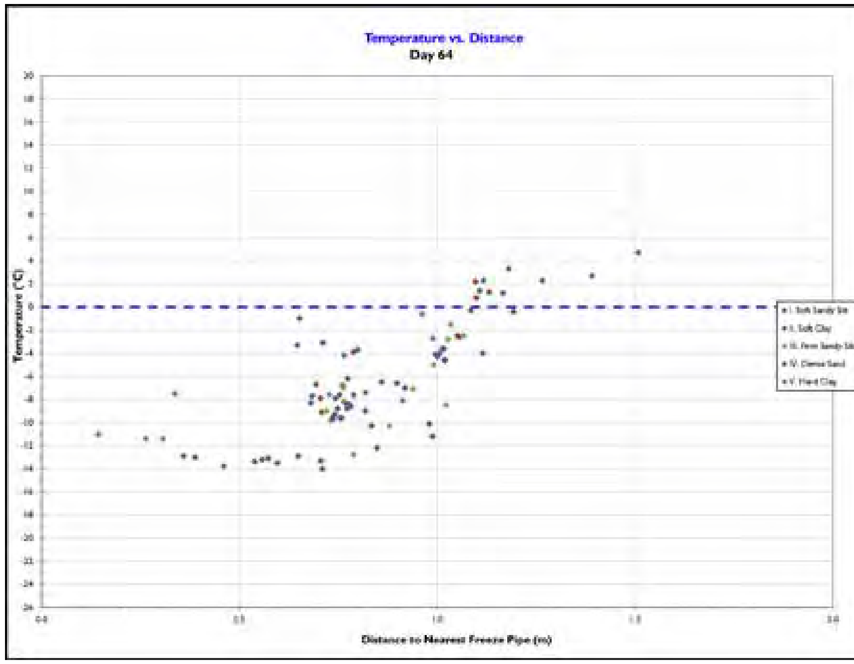


FIG. 8

After removing the tunnel segments, the joint venture prepared the base of the final liner.

closure. For confirmation, the shaft was evacuated in a controlled pump-down test over a period of four days. The water level of the shaft was continuously monitored and compared against the piezometer levels. This ensured that there was no communication between the water level inside the shaft and the phreatic surface outside.

Shaft excavation. Concurrent with the formation of the frozen soil wall, the JV installed the concrete reinforcing rings and the masonry plugs recommended by the structural engineer. Once the ground freezing subcontractor confirmed closure, the JV proceeded with installation of the final shaft liner. The soil around the tunnel was excavated, the tunnel segments were removed and a concrete slab at the base of the shaft was poured. Plugs of grout and soil were visible in some exposed slurry panel joints, as shown in Fig. 8. During the Argentine summer ambient temperatures reached as high as 36°C (97° F), but the ground freezing system kept the air temperature at the base of the shaft a cool 11.5° C (53° F).

The ground freezing system remained in operation until the JV installed the final shaft liner above the level of the known leaks in the slurry wall. The system was turned off after 147 days of operation. No noticeable heave or settlement was observed at ground surface.

Conclusion

When other ground improvement methods were unsuccessful in stopping the leaks at access shaft 3, ground freezing provided a unique solution. The difficult conditions on this project were overcome through collaboration and careful planning during the design, installation, and operation phases:

- The soil pressures did not cause any damage to either the tunnel or the shaft structures, validating the structural model.
- The estimated freezing time was in close agreement with actual field conditions, confirming the accuracy of the thermal model.
- After more than two years of difficulties, ground freezing enabled the joint venture to successfully excavate and construct access shaft 3. ■

Acknowledgments

The authors would like to recognize the parties that contributed to the project's success: Owner: Agua y Saneamientos Argentinos; General contractor: Aguas del Paraná UTE (Odebrecht, Roggio, Supercemento, Cartellone); Ground freezing subcontractor and designer: Moretrench American Corp.; Drilling subcontractor: Fundaciones Especiales; Structural consultant: Halcrow and Geotechnical consultants: Studio Geotecnico Italiano; Vardé & Asociados; Vecttor Projetos.

FEATURE ARTICLE

World's largest live tunnel connection at TARP McCook Tunnel

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

The construction of the tunnel system has been divided into two contracts. The gate and construction access shaft was completed in August 2011. The tunnel excavation and concrete and steel lining was completed in September 2014. The remaining and undergoing construction include the tunnel connections to the reservoir and the Mainstream Tunnel and installation of gates and hydraulic cylinders. This article focuses on the live connection of the McCook Main Tunnel to the Mainstream Tunnel that was initiated in November 2014 and will continue through the seasonal drier weather conditions in Chicago approximately from October through April.

FIG. 1

McCook Reservoir aerial view.

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Faruk Oksuz, member UCA of SME, and **Miguel Sanchez**, are project director/principal and project manager Black & Veatch; **Mike Padilla**, member UCA of SME, and **Dave Schiemann** are project manager and contractor office representative, U.S. Army Corps of Engineers, Chicago District; **Carmen Scalise**, member UCA of SME, is project director, Metropolitan Water Reclamation District of Greater Chicago and **Matt Trotter**, member UCA of SME, is project manager, Kiewit Infrastructure Company, email oksuzf@bv.com.

Chicago TARP system

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

The McCook Reservoir is the largest reservoir in the TARP system. Once completed, this $700-million reservoir facility will receive 38 billion L (10 billion gal) of CSO and flood water via the McCook Main Tunnel, which connects the TARP Mainstream Tunnel to the McCook Reservoir, and from distribution and Des Plaines inflow tunnels which will bring flow from the Des Plaines Tunnel of TARP.

McCook Main Tunnel layout

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

The McCook Main Tunnel is excavated in its entirety

FIG. 2

McCook Main Tunnel layout and components.

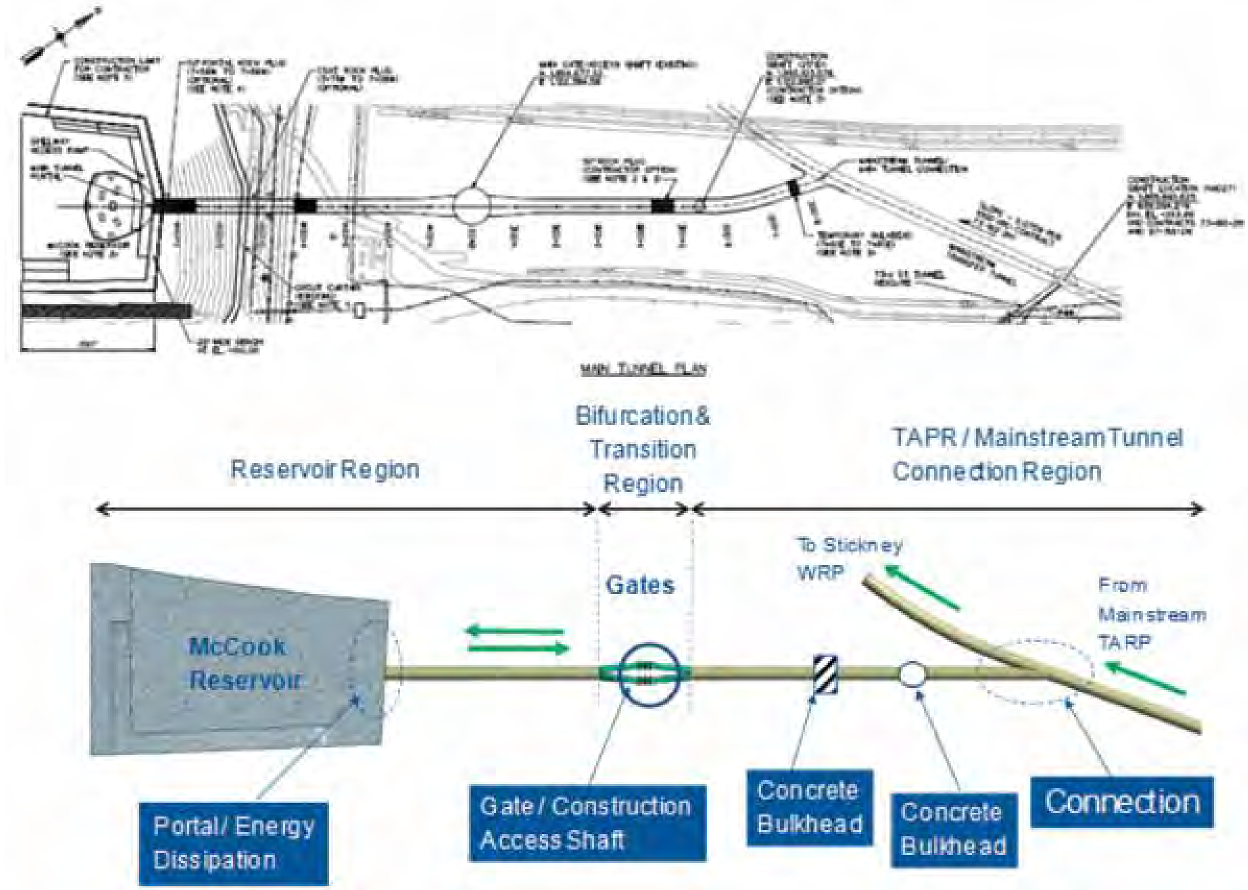


FIG. 3

Bifurcated and steel lined gate section of McCook Main Tunnel.

in bedrock, consisting of massive, relatively homogenous Silurian and late Ordovician dolomites. These rocks form a relatively uniform 100 + m (300 + ft) thick sequence across the site and incorporate the Racine Formation, Sugar Run Formation, Joliet Formation, Kankakee Formation, Elwood Formation and Wilhelmi Formation of Silurian age. The tunnel is located in the Kankakee and Elwood Formations.

The McCook Main Tunnel system has the following key components:

- Main tunnel section - Approximately 490 m (1,600 ft) long, 10 m (33 ft) inside diameter hard rock tunnel, bifurcated into two tunnels for 88 m (290 ft) through the gate shaft section.
- Main gate/access shaft - 27 m (88 ft) diameter, 90 m (295 ft) deep circular shaft located near midpoint of the main tunnel and houses the bifurcated tunnel section. This shaft was used for construction of the tunnel and houses the high head wheel gates for controlling flow between TARP Mainstream Tunnel and McCook Reservoir.
- Construction shaft (contractor option) - An optional, 7.6-m (25-ft) diameter, 87-m (285-ft) deep shaft was located at 91 m (300 ft) downstream or west of the mainstream tunnel connection. Kiewit elected to build this shaft to facilitate the live connection work even though it is not a requirement for operation of the system. As the tunnel and gate shaft excavation and lining were completed, a temporary concrete bulkhead was installed to isolate the live connection section from the rest of gate and reservoir works to the east.
- Gates - A total of six wheel gates operating under 100 m (300 ft) of water pressure head are being installed. Each gate measures 4.4 m by 9 m (14.5 ft by 29.5 ft) with associated hydraulic cylinders, power units, and associated gate controls. Each bifurcated section of the main tunnel contains one main gate and two guard gates — one upstream and one downstream of the main gate. The gates, hydraulic cylinders and controls were manufactured under a separate contract and were provided to the contractor as government furnished items. The gates were designed by Black & Veatch and fabricated by Oregon Iron Works.
- Main Tunnel/Mainstream Tunnel connection – This is the connection section of Main Tunnel to live Mainstream Tunnel. Main Tunnel was excavated to roughly 11 m (36 ft) diameter tunnel and broke through near the crown of existing 10-m (33-ft) diameter Mainstream Tunnel that remained in service. During design, the connection geometry was analyzed and evaluated to minimize potential turbulence and cavitation using computational fluid dynamics (CFD). As a result, the connection area has a flat-topped circular section from Station 7+07E to Station 8+52E. Live construction details are discussed in detail later in this article.
- Main Tunnel/McCook Reservoir connection – The Main Tunnel connection to the McCook Reservoir includes portal excavation and stabilization work at the quarry highwall face and an energy dissipation structure. The portal will be excavated from the reservoir side and will be supported with rock bolts, wire mesh and shotcrete.
- Control building – a surface facility to house gate operating controls, hydraulic power units and provide limited storage.

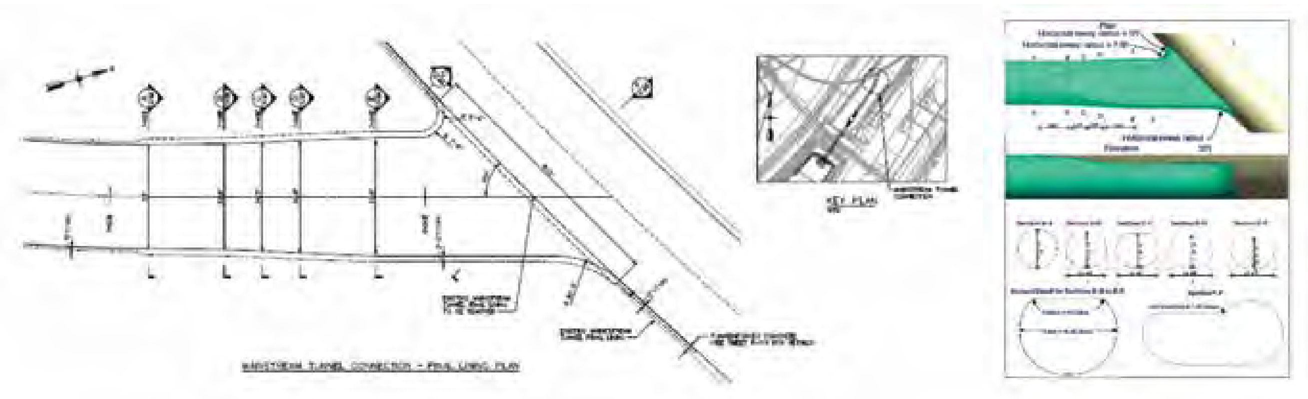
The McCook Main Tunnel system design, construction, operation and commissioning are coordinated with the overall McCook Reservoir water control plan as well as the reservoir excavation, quarry highwall stabilization, ground water protection system construction, and distribution and Des Plaines Inflow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

Live tunnel connection

The live connection to the Mainstream Tunnel has been challenging due to safety considerations and limited access as the tunnel has to remain in service at all times. The connection is located near the downstream terminus of the Mainstream Tunnel, which drains over 65 km (40.5 miles) of tunnel network virtually encompassing the highly developed city of Chicago. When it rains, the tunnel fills up rapidly with CSO and flood water. The MWRD operates

FIG. 4

Connection layout with CFD modeling allowed optimization of connection geometry for operations.



the tunnel system and the Mainstream pump station to collect and pump out the CSOs and subsequently treats the flows through the Stickney water reclamation plant. There is a constant base flow in the tunnel accounting about 113 to 150 million L/d (30 to 40 million gal/day) and MWRD uses a smaller pump set to evacuate the base flow or sometimes allows water to accumulate in tunnel until larger pumps are started up.

As required in the specifications, Kiewit has developed a comprehensive connection construction work plan for the live tunnel connection. Several partnering and weekly project meetings were held with Kiewit to review specifications, submittals, tunnel access conditions, and the entry and exit protocols. The tunnel access and construction work is required to be coordinated with MWRD's operations and adverse weather or rain conditions. Project safety has been number one priority to everyone and live tunnel access requirements are clearly defined and communicated to all parties involved.

Breakthrough and management of water

Kiewit designed a base flow bypass system consisting of upstream and downstream check dams (or half bulkheads) with a 914-mm (36-in.) nominal diameter HDPE bypass pipe across the connection section of the Mainstream Tunnel. Two probe holes were drilled into the connection heading to investigate for the presence of water and gases that may have been trapped between the end of the Main Tunnel excavations and the Mainstream Tunnel and to assess the presence and characteristics of potential gases and ventilation needs.

Once the tunnel access conditions were satisfied, the top heading of the Main Tunnel was excavated using controlled blasting and connected to the Mainstream

FIG. 5

Timber decking in Mainstream Tunnel.

Tunnel with a pilot tunnel. A ramp was constructed on the dry side of the pilot tunnel using the shot rock. Later, the pilot tunnel opening was enlarged with additional rounds of blasting and jack hammers. The ramp was kept at a higher elevation than Mainstream Tunnel invert to allow installation of a temporary work platform (access deck) using timber decking mats over the water in tunnel. Once initial steel set beams (W14 x 109) were anchored in place, 2.4-m (8-ft) wide and long, and 203-mm (8-in.) thick timber decking (or mats) were placed across the tunnel. The process is repeated until an approximately 24-m (80-ft) long access deck was completed. Top of the deck was approximately 4 m (12 ft) above the tunnel invert with water flowing below at approximately 1.2 to 1.5 m (4 to 5 ft) depth as MWRD was able to maintain pumping.

FIG. 6

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

Connection details

Following the installation of work platform, the connection work consisted of the following activities:

- Removal of the existing concrete liner in the tunnel arch using a hydraulic excavator with a breaking hammer and installation of ground support in the connection area. The muck was removed through the pilot tunnel opening and construction shaft.
- Excavation of the remaining pilot tunnel heading into the Mainstream Tunnel using slash and drift rounds.
- Extension of work platform to limits of existing liner replacement within Mainstream Tunnel.

FIG. 7

Bull nose at Main Tunnel (left) and Mainstream Tunnel Connection and concreting of invert toward Main Tunnel.

The existing nominal 305-mm (12-in.) thick unreinforced concrete liner was scribed with a radial saw cut at the limits of replacement that are established by the structural engineer's inspections and evaluation of field and lab test results.

- Assembled and installed 915 mm (36 in.) HDPE bypass piping on top of the deck. The pipe had fusion welded joints and was assembled on rollers on top of the access deck. Pipe support clamps were attached for securing the pipe to the liner once decking was removed.
- Installation of temporary check dams (or half bulkheads) consisting of steel piles, framework and steel plates in the Mainstream Tunnel at upstream and downstream locations. Tunnel water level was drawn down to lowest possible during installation of check dams.
- Installation of the bulkhead plates into the frames and lowering of HDPE pipe below decking.
- Excavation of the bench into the Mainstream Tunnel and matched inverts with Main Tunnel as shown on the drawings.
- Removal of the invert of the existing liner to the replacement limits. The radial sawcuts were continued along the invert of the existing concrete liner at the replacement limits.
- Installation of initial support components including resin grouted rock dowels and fiber reinforced shotcrete.
- Additional and as needed provisions for lighting, ventilation, monitoring for hazardous gases and care of water.

During the winter of 2014-2015, the liner removal was completed and approximately one-third of the tunnel was lined with reinforced concrete starting with the invert. The connection works were exposed to inundation more than 30 times where all personnel and equipment were evacuated out of the area upon notice from MWRD operators or the weather service dispatcher. All installations have survived the full flooding of the tunnel and remaining reinforcement and lining work will be completed in 2015-2016 winter season.

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

Conclusion

The connection work resumed in October 2015 and was expected to be completed within another one or two more dry seasons depending on time afforded with weather conditions and MWRD operations. At the time this paper is finalized, the team expects that most of the connection work is safely completed and as much as weather conditions permit.

Kiewit continues to work on other critical path duration activities on the project including installation of gates and portal work for reservoir connection and final reservoir preparations. The project team is actively engaged in other components and the Stage 1 of the McCook Reservoir, which is expected to be in service by the end of 2017. ■

Acknowledgments

The authors acknowledge the efforts and contributions of all project participants. In addition to authors listed for this article, we specifically acknowledge Gordon Kelly (USACE), Kevin Fitzpatrick (MWRD), Brent Bridges and Mark Petermann (Kiewit) and Charles Strauss and Clay Haynes (Black & Veatch) for their contributions to this paper.

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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	2016	Under study
2nd Ave. Phase 2-4	NYC-MTA	New York	NY	Subway	105,600	20	2017-22	Under study
Water Tunnel #3 bypass tunnel	NYC-DEP	New York	NY	Water	20,000	22	2015	Kiewit - Shea JV awarded
Water Tunnel #3 Stage 3 Kensico	NYC-DEP	New York	NY	Water	84,000	20	2017	Under design
Bergen Point Wastewater Outfall	Suffolk Co., DPW	Babalon	NY	Sewer	14,200	12	2017	Under design
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Highway	25,000	30	2016	Under study
South Conveyance Tunnel	City of Hartford	Hartford	CT	CSO	16,000	26	2015	Kenny/Obayashi JV awarded
Amtrak B&P Tunnel	Amtrak	Baltimore	MD	Rail	10,000	30	2018	Under design
Purple Line - Plymouth Tunnel	MD Transit Administration	Baltimore	MD	Subway	1,000	30x40	2015	PL Transit Const. low bid
Thimble Shoal Parallel Tunnel	Chesapeake Bay Bridge & Tunnel Dist.	Chesapeake	VA	Highway	5,700	45	2016	Dragados/ Schiavone low bid
Northeast Boundary Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	17,500	23	2017	Prequals submitted
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2017	Under design
Blacklick Creek San. Interceptor Tunnel	City of Columbus	Columbus	OH	Sewer	24,000	10	2015	Michels/Jay Dee JV low bid
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2017 2018	Under design Under design
Doan Valley Storage Tunnel	NEORSD	Cleveland	OH	CSO	9,700	17	2017	Under design
Westerly Main Storage Tunnel	NEORSD	Cleveland	OH	CSO	12,300	24	2020	Under design
Shoreline Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,100	21	2021	Under design
Southerly Storage Tunnel	NEORSD	Cleveland	OH	CSO	17,600	23	2024	Under design
Ohio Canal Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,170	27	2015	Bid date 4th Q 2015
Continental Rail Gateway	CRG Consortium	Detroit	MI	Rail	10,000	28	2015	Under design
ALCOSAN CSO Ohio River Allegheny River Monongahela River	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	10,000 41,700 53,900	30 30 30	2019 2020 2021	Under design Under design Under design
Three Rivers Protection/Overflow	City of Fort Wayne	Fort Wayne	IN	CSO	26,400	12	2016	Prequals submitted
Deer Creek Sanitary Tunnel	St. Louis MSD	St. Louis	MO	CSO	21,000	19	2016	Bid date 8/25/16

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Lower & Middle River Des Peres Storage Tunnel	St. Louis MSD	St. Louis	MO	CSO	47,500	30	2020	Under design
Lower Meramec Tunnel	St. Louis MSD	St. Louis	MO	CSO	35,900	8	2020	Under design
Minne Lusa Tunnel	Omaha Public Works	Omaha	NE	CSO	28,500	17	2017	Under design
Mill Creek Peaks Branch Tunnel	City of Dallas	Dallas	TX	CSO	5,500	26	2014	To be rebid
Palmer Lane Interceptor Tunnel	City of Austin	Austin	TX	CSO	12,000	8	2016	Bid date 9/16/2016
Ballard to Wallingford Tunnel	Seattle Public Utilities	Seattle	WA	CSO	14,250	14	2018	Under design
L.A. Metro Westside Extension Phase 1 Phase 2 Phase 3	Los Angeles MTA	Los Angeles	CA	Subway	42,000 26,500 26,500	20 20 20	2014 2016 2017	Skanska/Traylor, Shea awarded No award to date Under design
Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2017	Under study
Northeast Interceptor Sewer 2A	LA Dept. of Water and Power	Los Angeles	CA	Sewer	18,500	18	2014	Under design
River Supply Conduit - Unit 7	LA Dept. of Water and Power	Los Angeles	CA	Water	13,500	12	2015	Under design
JWPCP Effluent Outfall Tunnel project	Sanitation Districts of LA	Los Angeles	CA	Sewer	37,000	18	2015	Advertize 4Q 2016
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2016	Under design
BDCP Tunnel #1 BDCP Tunnel # 2	Bay Delta Conservation Plan	Sacramento	CA	Water	26,000 369,600	29 35	2017 2018	Under design Under design
SVRT BART	Santa Clara Valley Trans Authority	San Jose	CA	Subway	22,700	20	2016	Redesign activated
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2015	Advertize 3Q 2017
Keswick Effluent Outfall	City of Toronto	Toronto	ON	CSO	11,600	23	2018	Under design
Yonge St. Extension	Toronto Transit Commission	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	2017	Under design/ delayed
CSS - East-West	City of Ottawa	Ottawa	ON	CSO	14,400	10	2015	Dragados/RW Tomlinson low bid
Green Line LRT	City of Calgary	Calgary	AB	Traansit	26,250	20	2018	Under design
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Under design
Annacis Island Outfall	City of Vancouver	Vancouver	BC	Water	8,000	10	2017	Under design
Burnaby Mountain	Kinder Morgan	Vancouver	BC	Oil	8,000	12	2017	Under design
UBC Line project	Trans Link	Vancouver	BC	Subway	12,000	18	2015	Under design
Northern Gateway Clore Tunnel Hoult Tunnel	Enbridge Northern	Kitimat	BC	Oil Oil	23,000 23,000	20 20	2014 2014	Under design Under design

EXECUTIVE COMMITTEE

Highlights of the UCA Executive Committee meeting

The Executive Committee of the UCA of SME met during the World Tunnel Congress (WTC) in San Francisco, CA on April 28, 2016. After the WTC, the board confirmed the new slate of officers for the coming year by electronic ballot: Arthur Silber, chair; Michael Roach, vice chair and William Edgerton, past chair. New directors include: Jack Brockway, Richard Redmond, Michael Smithson and Erika Moonin.

The committee reviewed the current state of business affairs for the UCA. The *History of Tunneling* book is expected to be published by the end of 2016. Complimentary copies are available to attendees of WTC 2016. The WTC 2016 conference experienced the greatest number of registrations and exhibits in the history of the World Tunnel Congress. Attendance exceeded expectations, with more than 2,300 visitors from 54 countries converging at the week-long event. A record-setting 298 exhibit booths showcased the most current products and technical developments in the world. Significant volunteer contributors to the success of the WTC will be recognized during the Moles dinner at the 2017 George Fox Conference in New York City, NY.

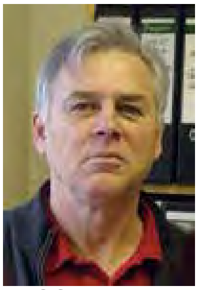
The Outreach Subcommittee is considering two ways to expand the educational opportunities for young professionals and young professors studying and teaching underground construction and tunneling. UCA is considering a teach-the-teachers workshop for up to 20 young professors prior to RETC 2017 that will provide actual curriculum to teach underground construction and tunneling. A second suggestion is to create a list of speakers available to make presentations to university classes. These speakers will carry a message of career opportunities in the underground construction and tunneling industries to students and prospective employees.

The UCA of SME also gave WTC 2016 attendance scholarships to more than 50 students to foster additional student involvement. All were excited about attending and learning about the opportunities in the underground industry, and they were appreciative of the scholarships that enabled them to attend a conference during the school year. Without the scholarship, only a few of the students could have attended. ■

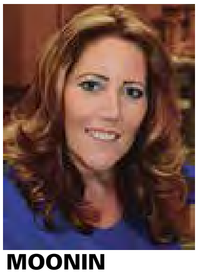
Four new directors join UCA Executive Committee

Jack E. Brockway, Erika P. Moonin, Richard Redmond and Michael Smithson joined the UCA Executive Committee on July 1, 2016.

JACK E. BROCKWAY, P.E., is president of Herrenknecht Tunnelling Systems USA and Canada, H+E USA (conveyors) and VMT USA (guidance systems). He is responsible for all Herrenknecht tunnel boring machines (TBM) and related mining business in North America. He is a graduate of the University of Washington and a registered professional engineer (mechanical) in Washington. He joined the TBM industry in 1973 and has held a variety of positions in engineering, marketing and business management, all specific to the supply of TBMs worldwide. Since joining Herrenknecht 20 years ago, his primary focus has been tunneling and mining projects for North America.


BROCKWAY

ERIKA P. MOONIN, P.E., D.WRE, is a licensed professional engineer in the states of Nevada and California. She graduated from the University of Nevada-Las Vegas with a bachelor of science degree in civil engineering. She started her career working for an engineering consulting firm and now has more than 20 years of experience working for the Las Vegas Valley Water District and the Southern Nevada Water Authority (SNWA). She also has volunteered for the past 25 years for the American Society of Civil Engineers, serving in many local branch, region and national board committee positions. She is currently the engineering project manager for the SNWA's Lake Mead Intake No. 3 project, estimated at approx. $1.4 billion, that will ensure the water supply for Las Vegas Valley.


MOONIN

RICHARD REDMOND, P.E., is president of Redmond Construction Engineering in Garden City, NY. He has more than 35 years experience as a contractor and construction manager, cost estimator and dispute resolution board chairman for major underground and transit projects in the United States.


REDMOND

Notable projects include the NYC Water Tunnel #3, MTA 7 Subway Extension , MTA 2nd Ave Subway, San Francisco Central Subway and LA Metro Regional Connector.


SMITHSON

MICHAEL SMITHSON is a senior vice president with Skanska USA Civil. He is responsible for Skanska's underground heavy civil projects in the western United States, including the Regional Connector and Westside Subway Extension, Contract 1 for the Los Angeles County Metropolitan Transportation Authority. In addition, he serves as the project director for the Regional Connector project. He has more than 24 years of geotechnical engineering and underground construction experience with 22 years of experience working for underground and tunnel contractors. Prior to joining Skanska in 2012, he worked for Kenny Construction in Chicago, IL.

Smithson received a B.S. in engineering from Purdue University and an M.S. in civil engineering from the University of Illinois. He is a licensed professional engineer in the Ohio. He has held leadership roles with the NAT Conference and was conference chair for the WTC 2016 in San Francisco, CA. ■

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 2017 to 2021. 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 Spencer Chase (chase@smenet.org) at SME headquarters by Nov. 28, 2016. 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. ■

PERSONAL NEWS


MACDONALD

RICHARD D. MACDONALD JR. has been elected the 2016-2017 president of The Moles. MacDonald is senior vice president and division manager for the Construction Division of Weeks Marine. He is responsible for projects along the U.S. East Coast, Gulf Coast, Latin America and the Caribbean.

McMillen Jacobs Associates has announced the addition of several key staff. **JAMES WONNEBERG**, P.E., CCM, (SME) joined the Seattle, WA office as a lead associate, providing support to the Washington State Department of Transportation as resident engineer on the SR 99 Alaskan Way Viaduct replacement project. Wonneberg started his career in Chicago, IL then relocated to Seattle in 2008 for the Brightwater Central Tunnel and Influent Pump Station projects. In 2011, he moved to Washington D.C. for the Blue Plains Tunnel, part of the DC Clean Rivers Project, where he had the opportunity to see the project through from notice to proceed to final completion. **MARK FUNKHOUSER**, P.E., joined the Cleveland, OH office as a principal-geotechnical engineer. He has 30 years of international experience specializing in geotechnical and rock mechanics engineering. **PETER RALEIGH**, C.Eng., P.E., returns to McMillen Jacobs Associates as a lead associate in the Cleveland office. He recently served as construction manager on the Green Line Underground project in Doha, Qatar. **BRIAN**


WONNEBERG

LAUSH, lead associate, has joined the SR 99 Alaskan Way Viaduct Replacement Project in the Seattle, WA office providing project controls on the project. **DOUG GRIMES**, P.G., PMP, joined the firm's Vancouver office as an associate. He has more than 25 years of experience in technical and project management roles on hydropower, dam safety, mining, water supply, environmental and reclamation projects. **JAE BATEMAN,** CP, joined the Sydney, Australia office as an associate focusing on major tunneling works in Australia. He has worked extensively in mining and geotechnical engineering.

NASRI MUNFAH (SME) has been appointed a senior vice president and director of global tunneling at WSP Parsons Brinckerhoff. He will be responsible for developing a long-term strategic plan to advance the firm's tunneling practice nationally and globally. Munfah has more than 30 years of experience in tunneling and underground engineering


MUNFAH

and project management experience in transportation, transit and underground engineering. He is a principal investigator and a co-author of Federal Highway Administration *Tunnel Design Manual.* Previously, Munfah was chairman of HTNB Tunnel Services. ■

UCA YOUNG MEMBERS

Join UCA Young Members

Join the UCA Young Members group in supporting the growth and development of young engineers and professionals in the tunneling and underground construction industry who are interested in learning more about the profession, developing technical skills to use in the field, and sharing innovative technologies and research with the membership. The group consists of young people who believe that the stability of the industry depends on the next generation of professionals. Join us for free monthly webinars and become a member of our SME community group (UCA Young Members) to keep up-to-date on university outreach, social events and discussions. More information can be found at http://community.smenet.org/ucaym/home. ■

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