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TUNNELING & UNDERGROUND CONSTRUCTION

THE OFFICIAL PUBLICATION OF UCA OF SME WWW.TUCMAGAZINE.COM VOLUME 9 NO 3 SEPTEMBER 2015

TBM mining at Deep Rock

Lake Mead Intake No. 3

ITA explained

Special Editorial Section from the publisher of Mining Engineering

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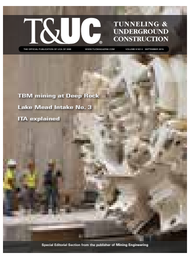

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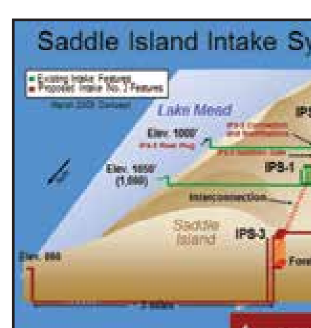


DEPARTMENTS

 TUNNELING & UNDERGROUND CONSTRUCTION (ISSN 0026–5187) is published quarterly by the Society for Mining, Metallurgy, and Exploration, Inc., at 12999 E. Adam Aircraft Circle, Englewood, CO 80112-4167. Phone 1–800–763–3132 or 303–973–9550. Fax: 303–973 –3845 or e-mail: sme@smenet.org. Website: www.smenet.org. **POSTMASTER:** Send changes of address to TUNNELING & UNDERGROUND CONSTRUCTION, 12999 E. Adam Aircraft Circle, Englewood, CO 80112-4167. Article copies and back issues available on microfilm or microfiche from Linda Hall Library in Kansas City, Mo. Printed by Cummings Printing Co.

CHAIRMAN'S COLUMN

WTC 2016 is around the corner

First and foremost, I want to thank the entire UCA of SME Executive Committee for it's confidence in me and for electing me as chair. My personal thanks to past chairs, such as Bill Edgerton, Jeff Peterson, Dave Klug and others, for their excellent leadership over the years. Also, a big thank you to Dave Kanagy and the entire UCA of SME staff for all they do to help us serve the underground community of contractors, engineers, suppliers, owners and educators.

The 2015 Rapid Excavation and Tunneling Conference (RETC) was held in New Orleans, LA in early June, and it was a tremendous success, with 1,250 attendees and 157 exhibitors. The 113 papers presented were well received, and many attendees had positive comments on the innovative procedures being implemented to achieve successful projects. A big thank you goes to the conference chair and working groups who brought everything together for a spectacular conference. As always, the lessons learned from the event will be used to improve future RETC, North American Tunneling, Cutting Edge and George A. Fox conferences.

Our underground industry is very busy these days, advancing many types of infrastructure facilities including roadway tunnels, rail tunnels, water distribution tunnels, utility tunnels and CSO tunnels, as well as rehabilitating many aging facilities. As our work continues to grow, so must our personnel and their expertise. It is through our organization that new and innovative techniques must be shared for the benefit of our clients and the ultimate users of the facilities we bring to fruition. Sharing techniques via our conferences and publications is vital so that we, as an entire industry, can grow in our ability to assist our clients.

At the last UCA Executive Committee meeting following the RETC, a new scholarship committee led by Mike Roach was created. I want to encourage all UCA members to reach out to their staffs, friends, neighbors and students to encourage scholarship candidates to submit applications for review and consideration by the committee later this year. An application can be found at http://uca.smenet.org/scholarships.

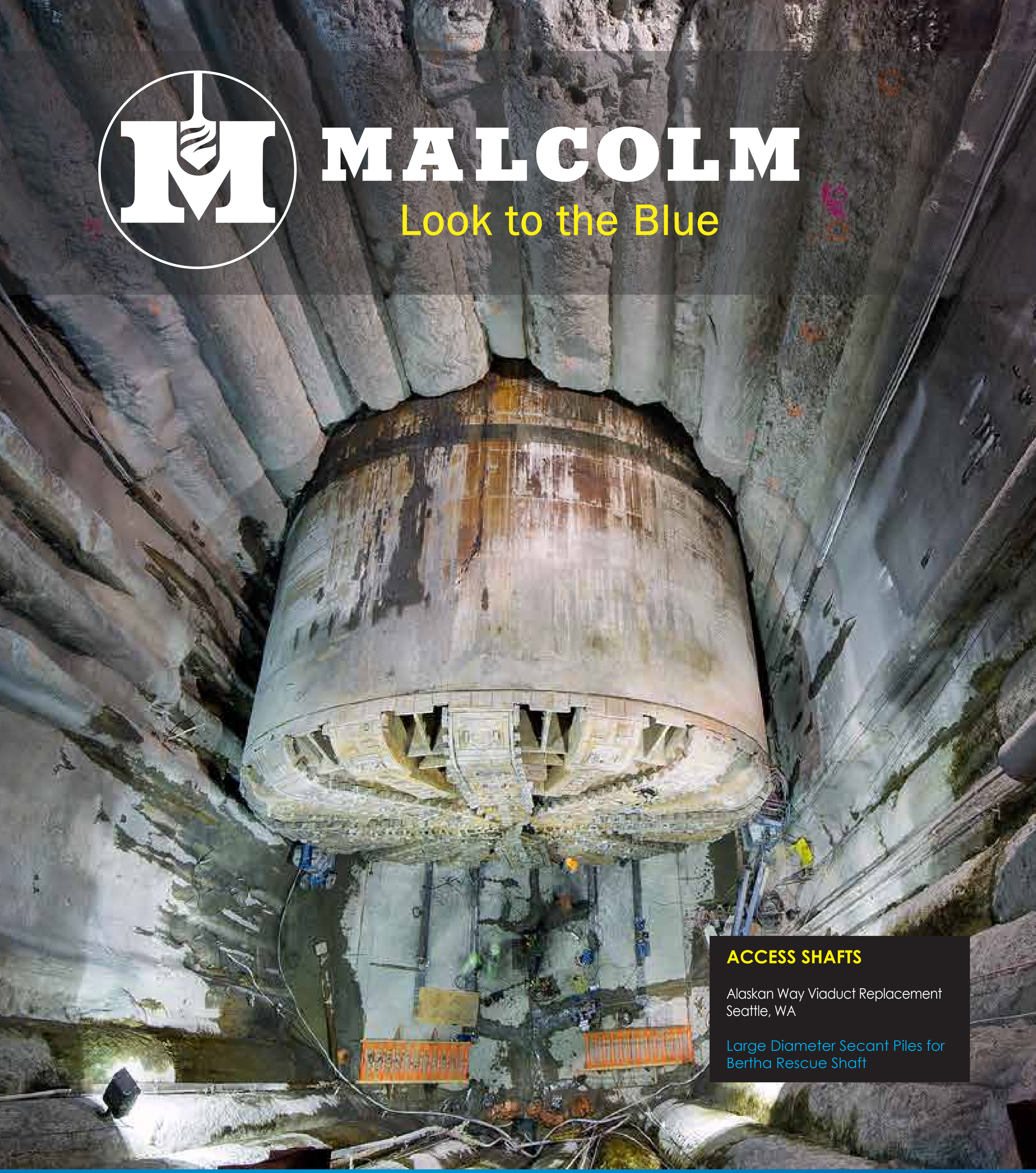
The Young Tunnelers members group and the Women in Tunneling group are gaining momentum. Our organization fully supports them and encourages greater participation. We have already committed funding and other support to both groups, and the executive committee is asking all members to assist them whenever possible as we grow our Association's diversity.

Nearly four dozen UCA members and staff attended WTC 2015 in Croatia. The sessions and networking opportunities were tremendous and many observations were made and recorded. We are very fortunate that WTC 2016 will be combined with our NAT 2016 to be held in San Francisco, CA on April 22 to 27, 2016. Mark your calendars and find out more at www.wtc2016.us/.

Many of our organization's members are busy finalizing arrangements for this world-class event. The 2016 conference chairs are busy making necessary preparations, appointing manuscript reviewers, arranging the spouse/guest tours and events and preparing a coffee table book for distribution to all attendees. This event will be an opportunity for the United States to shine and to raise the bar for all future World Tunneling Congresses.

Registration and hotel booking is now open, along with the opportunity to select vendor booth space, which is selling quickly. Please take steps to reserve your space soon. I'll see you there. ■

Artie Silber,
UCA of SME Chair


MALCOLM
Look to the Blue
ACCESS SHAFTS
Alaskan Way Viaduct Replacement
Seattle, WA
Large Diameter Secant Piles for
Bertha Rescue Shaft

US transportation secretary opens discussion about Gateway Project

Following consecutive days of train delays that locked up parts of the New Jersey Transit systems in July, U.S. Transportation Secretary Anthony Foxx reached out to the governors of New York and New Jersey urging them to meet with him to map out a strategy to advance on the long-stalled plans for new Hudson River rail tunnels.

The current tunnels used by New Jersey Transit and Amtrak to traverse the Hudson are 100 years old and many feel they need to be replaced.

The New York Times reported that Foxx asked Gov. Chris Christie of New Jersey and Gov. Andrew M. Cuomo of New York to meet to discuss their states' roles in a proposal, known as the Gateway Project, to build new rail tunnels.

"The condition of the trans-Hudson tunnels is a major threat to the region and to our nation's transportation system," Foxx wrote. "I write to urge immediate action and to lend my personal engagement to get the Gateway tunnel project on the path to completion as soon as possible."

In 2010, the project to build new tunnels under the river known as Access to the Region's Core (ARC) was shelved by Christie who cited concerns that New Jersey would be held responsible for cost overruns. A spokesman for Christie, Brian Murray, told *The New York Times* that the governor was happy to meet with Foxx and Cuomo.

"He has always been and remains committed to expanding cross-Hudson capacity, so long as it is equitably funded by everyone who benefits regionally and not disproportionately on New Jersey taxpayers as the ARC project was," Murray said in a statement.

In June, transportation officials from the region supported the project in a letter to Foxx, asking for the Gateway Project to be considered for a federal program that helps provide financing strategies for infrastructure projects.

Amtrak officials say the current tunnels need to be closed for repairs because of damage from Hurricane Sandy, but that closing one of the two tunnels would substantially reduce the number of trains that could travel between New York and New Jersey, especially during morning and evening rush hours.

On a trip to New York City, Foxx said the Gateway plan was one of the most important rail projects in the country, and he called the lack of action to repair the tunnels "almost criminal." Since 2010, Christie, a Republican who is running for president, has not put any political muscle behind restarting the projects, which would cost billions of dollars when the state already faces a growing backlog of urgent but unfunded transportation projects.

In his letter, Foxx said that the Obama administration was willing to explore federal financial assistance for the project. The Federal Railroad Administration and Amtrak have discussed financing tools to get the project started, he said, but they needed support from the states.

"Neither Amtrak nor your individual states, acting alone, can replace these tunnels," he wrote. "It will take all of us working together."

At an event in Manhattan where Cuomo, a Democrat, and Vice President Joseph R. Biden Jr. announced an overhaul of La Guardia Airport, Biden, who as a senator was a regular on Amtrak trains, briefly touched on the problems of the Hudson River tunnels and the need for collective action.

> **"The condition of the trans-Hudson tunnels is a major threat to the region and to our nation's transportation system. I write to urge immediate action and to lend my personal engagement to get the Gateway tunnel project on the path to completion as soon as possible."**
>
> **U.S Transportation Secretary Anthony Foxx, in a letter to the governors of New York and New Jersey**

"I'd ask Governor Christie to come back and talk about it," Biden said.

In a letter to Foxx, the officials from New Jersey and New York said the Gateway Project was an "urgent necessity." The June 26 letter was signed by an array of transportation officials: Amtrak's president, Joseph H. Boardman; New Jersey Transit's chairman, Jamie Fox; New York's then-transportation commissioner, Joan McDonald; the Metropolitan Transportation Authority's chairman, Thomas F. Prendergast; New York City's transportation commissioner, Polly Trottenberg; the Port Authority of New York and New Jersey's executive director, Patrick J. Foye; and New Jersey Transit's executive director, Veronique Hakim.

"We stand ready to participate in the broad and equitable collaborative effort that will be needed among all sectors of government and private industry to improve the rail infrastructure of the Northeast Corridor as indicated," the letter said.■

Seattle Tunnel Partners announce new schedule for Bertha

As the tunnel boring machine (TBM) gets closer to being repaired, Seattle Tunnel Partners released an updated schedule for the SR-99 project that puts the completion of the tunnel in the spring of 2018, 27 months behind the original schedule.

Seattle Pi reported that the TBM, called Bertha, was expected to resume digging the nearly 3.2-km (2-mile) tunnel beneath Seattle, WA on Nov. 23, about 24 months after it came to a stop 300 m (1,000 ft) into the dig.

While project planners were able to set a new schedule, they have not been able to say for sure how much over its $3.1 billion budget the project might go, and it's unclear how those costs will be divvied up by the contractor.

"That's all going to be sorted out within the contract requirements, so that's something that occurs sometime in the future," said Chris Dixon, project manager for Seattle Tunnel Partners, the contractor digging the tunnel. "The focus now is to get the TBM repaired, up and running so we can complete the tunnel drive."

Washington Department of Transportation officials said the state cannot verify the contractor's schedule, but they have confidence in the new schedule and will keep a close eye on progress to make sure things are going forward as promised.

The details of the schedule are the responsibility of Seattle Tunnel Partners, said Todd Trepanier, the state DOT's Alaskan Way Viaduct Replacement Program administrator.

"We've asked them to give us a tunnel with a roadway in it," Trepanier said. "They've made the decision on how they're going to do that."

Changes to the schedule — and any costs that go with that — fall on Seattle Tunnel Partners, not

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PERFORM AT A HIGHER LEVEL
Putzmeister

DC Water's first TBM completes 4.5-mile tunnel for cleaner Anacostia River

DC Water's 7.2-km (4.5-mile) long tunnel was completed with the breakthrough on July 23 of the tunnel boring machine (TBM) called Lady Bird.

The tunnel will be used to help improve the water quality in the Anacostia River. Lady Bird completed her dig and her cutterhead was extracted from a 30-m- (100-ft-) deep shaft near DC Water's Main Pumping Station in Southeast Washington, DC.

Tunneling began in July 2013, from a starting point at the Blue Plains Advanced Wastewater Treatment Plant. Lady Bird tunneled along the Potomac River northward to Poplar Point and then crossed under the Anacostia River and continued west, finishing at a deep shaft along Tingey Street, SE. To prepare for her arrival, this shaft was filled with flowable fill concrete and water, to protect against changes in pressure as Lady Bird mined through the shaft wall.

"This is a terrific milestone for DC Water's Clean Rivers Project," said DC Water chief executive officer and general manager George S. Hawkins. "We are fortunate that the tunneling went so smoothly, finishing on time and on budget, and I applaud our DC Water staff as well as Traylor Skanska Jay Dee and everyone else who took part in this successful dig."

DC Water's Clean Rivers Project will incorporate two methods to keep combined sewage and stormwater from overflowing into waterways, during heavy rains in the parts of the city with a combined sewer system. The first is to build underground tunnels that will hold combined sewage and stormwater until rain subsides, then convey it for treatment at Blue Plains. The second is to create green infrastructure to capture and

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Tunneling efforts on Crossrail Project complete

It was a monumental effort that included eight tunnel boring machines (TBM) and took nearly three years for the 42-km (26-mile) tunneling portion of the Crossrails Project to be completed in June.

The British Prime Minister David Cameron and Mayor of London, Boris Johnson, celebrated the completion of Crossrail's tunnels by going 40 m (131 ft) below the capital to thank the men and women who are constructing the new £14.8 billion east-west railway.

"Crossrail is an incredible feat of engineering that will help to improve the lives of working people in London and beyond. The project is a vital part of our long-term plan to build a more resilient economy by helping businesses to grow, compete and create jobs right along the supply chain," said Cameron.

Crossrail tunneling began in the summer of 2012 and ended at Farringdon with the break through of tunneling machine Victoria, one of the eight 1-kt (1,000-st) TBMs that bored the new 6.2-m (20-ft) diameter rail tunnels under London.

Construction is also advancing on the 10 new Crossrail stations and on works above ground west of Paddington and east of Stratford. More than 10,000 people are currently working on Crossrail, including more than 450 apprentices.

With the arrival of Crossrail in 2018, Farringdon will become one of the UK's busiest rail hubs with direct connections to London Underground and upgraded and expanded Thameslink services. This brand new interchange will transform the way passengers travel through London and the South East, providing more capacity and direct connections to three of London's five airports and international rail services at St Pancras.

Crossrail will add 10 percent capacity to London's rail network. It will serve 40 stations, connecting Reading and Heathrow in the west with Shenfield and Abbey Wood in the east. Transport for London (TfL) run Crossrail services through central London will commence in December

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Bechtel-led team begins work on $10 billion Riyadh Metro Project

Bechtel will lead a global consortium on the construction of the Riyadh Metro project in Saudi Arabia, one of the largest underground rail systems in the world.

Bechtel has already begun tunneling on Line 1 of the Riyadh Metro, marking an important milestone in the construction of this landmark project, *Reuters* reported.

The Bechtel-led consortium, which includes Saudi company Almabani General Contractors, Middle East-based Consolidated Contractors Co., and Germany's Siemens AG, is responsible for the $10-billion contract for the design, construction, train cars, signaling, electrification and integration of Lines 1 and 2 — two of the most challenging lines on the Riyadh Metro Project. The work includes 39 stations, two of which are key interchange stations: Olaya Station, situated in the center of Riyadh at the intersection of Lines 1 and 2, and King Abdullah Financial District Station, located slightly to the north on Line 1.

"The metro, set to be the cornerstone of Riyadh's new public transport network, will revolutionize how people move around the city," said Amjad Bangash, Bechtel's director on the project. "Sending our team's first tunnel boring machine on its underground voyage is a significant step for all."

Bangash said the tunneling work beneath the streets of the Saudi capital will prove challenging. "Getting early agreement on the alignment in the heart of the city was crucial to advance the detailed design work needed to start tunneling. We appreciate the efforts that our client, Arriyadh Development Authority (ADA), and many other stakeholders undertook in helping us achieve this."

The first tunnel boring machine, Mneefah, named after the horse of Saudi Arabia's founder King, will steadily ramp up to its planned average tunneling rate of about 100 m/week (325 ft/week) and is expected to complete its journey by mid-2016. In total, seven tunnel boring machines will be deployed by the Bechtel-led team to dig and construct

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Seattle: TBM expected to be running in November

(Continued from page 06)

taxpayers, Trepanier said.

Dixon said it's still unclear exactly what caused the breakdown of Bertha, but he has confidence that, with repairs and upgrades meant to make the machine work better, it will complete the tunnel.

"We're doing something here that's unprecedented," he said. "We're tunneling with the world's largest tunnel boring machine, it's essentially a prototype, there's never been one manufactured like it before. We think it's better to take more time and do it right."

> **We're doing something here that's unprecedented. We're tunneling with the world's largest tunnel boring machine, it's essentially a prototype, there's never been one manufactured like it before. We think it's better to take more time and do it right."**
>
> **Chris Dixon, project manager, Seattle Tunnel Partners**

Bertha will resume digging almost two years to the day after getting stuck and breaking down Dec. 6, 2013.

Despite that delay, work has continued on both the south and north ends of the project and workers have completed 128 m (432 ft) of what will be the southbound upper deck in the section of tunnel behind Bertha.

At the south end of the tunnel, about 640 m (2,100 ft) of cut-and-cover — essentially the entrance to the tunnel — is already dug, with part of it covered.

Entering the actual tunnel, emergency and utility access tunnels line one side of the area that will eventually be the northbound lower deck, and water drips in from underground aquifers that surround both the entrance and the tunnel itself. Later, the whole thing will be sealed up.

Extensive repairs and upgrades should be completed in the fall, and then the cutting head will be lowered back into the pit and reinstalled before two months of testing takes place, Dixon said. ■


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Construction begins on Hawaii's longest tunnel

In the spring of 2015, by the idyllic shores of Oahu, HI, a Robbins 3.96-m (13-ft) diameter main beam tunnel boring machine (TBM) began its long journey. The TBM started its excavation on a 4.6-km (2.8-mile) drive for a new sewer tunnel in Kaneohe, Honolulu, HI. The machine, nicknamed Pohakulani, meaning "Rock Girl" in Hawaiian, launched from a 23-m (74-ft) deep starter tunnel on a mission to bore through almost 4.8 km (3 miles) of basalt bedrock. Contractor Southland/Mole JV is building the Kaneohe-Kailua wastewater conveyance tunnel for the city and council of Honolulu, which will improve waste water infrastructure by eliminating overflows during rain events.

On April 30, 2015 in Honolulu, HI, a Robbins Main Beam TBM began a 4.6-km (2.8-mile) drive for a new sewer tunnel.

The deep tunnel option was not the first design considered for the project. Preliminary plans called for a smaller tunnel traveling under the bay. As Kaneohe Bay is an environmentally sensitive area, a deep tunnel remained an attractive option. Richard Harada, of project consultant Wilson Okamoto Corp., explained the ultimate decision, "A number of factors were considered in making the decision to build a deep tunnel including reliability, construction costs, life cycle costs, environmental impacts, constructability and qualified

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DC Water: Clean Rivers Project advancing

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infiltrate rain on-site before it can reach the combined sewer system.

Carlton Ray, director of the DC Clean Rivers Project, added, "Lady Bird performed as well as projected—having a one-day best mark of 45 m (150 ft). In her best week, she tunneled 192 m (631 ft). This TBM's success means we are one step closer to a cleaner Anacostia River."

Lady Bird dug the southernmost segment of the Anacostia River Tunnel. The next section will be mined by another TBM named Nannie, who is preparing to begin her tunnel at a site near RFK Stadium. The Northeast Boundary Tunnel is the longest portion of tunnel, and that contract has yet to be awarded. At the northern tip of the tunnel system is the First Street Tunnel, a relatively short tunnel that will be mined by Lucy, and is designed as a flood protection project for the Bloomingdale and LeDroit Park neighborhoods.

Lady Bird removed approximately 1.1 Mt (1.2 million st) of material that she mined. This was hauled away in nearly 72,000 truckloads over the last two years. She built the tunnel with 28,189 pre-cast concrete segments which made up 4,027 full rings.

The cost of tunnel boring machines is included in the contract for each tunnel segment. Therefore, the TBMs are owned by the contractors for each tunnel portion. Lady Bird is the property of the contractor and can be extracted and used on another project. Lady Bird is being sold back to her German manufacturer, Herrenknecht. ■

Coming Up

2015 Cutting Edge: Urban Tunneling

Sept. 21-24, 2015
The Grand Hyatt, Denver, CO

http://www.ucaofsmecuttingedge.com

Crossrail: Project will serve growing population

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2018. An estimated 200 million passengers will travel on Crossrail each year.

"This is a landmark moment for London that puts us a gigantic step closer to the launch of an absolutely vital new railway, which will hugely improve our ability to speedily move people across our city," Mayor Johnson said. "Crossrail has already created tens of thousands of jobs and helped boost the skills of many thousands of people, not just in the capital, but all around our great nation. It is a wonderful example of our nation's talent for engineering, a talent that must not be allowed to founder and that I hope will eventually be put to use on the construction of Crossrail 2."

Terry Morgan CBE, Crossrail chairman, said, "Crossrail is the most significant addition to London's transport network in a generation and one of the most ambitious infrastructure projects ever undertaken in the U.K. The completion of Crossrail tunneling is a truly significant milestone and would not have been possible without the support and commitment of London, our contractors and everyone who works on Crossrail."

London's population is set to grow from 8.4 million today to around 10 million by 2030. The government, the mayor of London and TfL are investing in Crossrail and other transport infrastructure to support access to jobs, education, housing and to boost economic growth. Crossrail is part of TfL's investment program.

Crossrail is a vital part of the government's commitment to invest record amounts in the rail network as part of its long-term economic plan. Between 2014 and 2019, more than £38 billion will be spent on improving and maintaining the U.K.'s railways.

Over the course of the project, it is estimated that Crossrail and its supply chain will support the equivalent of 55,000 full time jobs across the country.

A total of 84,300 jobs were supported last year across the U.K, through TfL's investment program and Crossrail. TfL and its suppliers have also created more than 5,000 apprenticeship roles since April 2009. ■

Robbins: TBM expected to be running in November

(Continued from page 16)

contractor availability."

During the tunnel design phase, it was decided that the tunnel route should travel inland and deeper underground in order to bypass one of the few residential areas along the alignment. Designers introduced an isolated curve in the tunnel alignment of 150 m (500 ft) radius, requiring the TBM to be designed with a unique backup system. There will also be operational procedures when crews navigate the tunnel curve, requiring the machine to be operated using half strokes rather than a full TBM stroke.

The curve is not the only unusual aspect of the tunnel. In fact, a tunnel on this scale has not been built in the Hawaiian Islands before. Everything from the logistics of the tunnel operation to pregrouting sections ahead of the TBM for ground water control are new to the Aloha state. Director of Southland, Tim Winn, elaborated, "There has not been a tunnel boring machine of this size in the Hawaiian Islands or a tunnel of this length. The tunnel is being driven from an active water treatment plant (WTP), and space is at a premium. There are also simultaneous contracts being performed there outside the scope of our work." He added that although there have been challenges, teamwork has been key: "Robbins Field Service has been extremely valuable during assembly and commissioning of the TBM." As of June 2015, the TBM had excavated more than 300 m (1,000 ft), and is boring at a rate of 12 to 15 m (40 to 50 ft) per day in basalt rock. Rock bolts, steel arches, wire mesh, and ring beams are being installed as necessary.

Upon completion, the deep tunnel will enhance water treatment capabilities and further aid in ceasing noncompliant, uncontrolled or moderately treated wastewater discharges. The main beam TBM is estimated to end its journey in eight to 10 months at the Kaneohe waste water pre-treatment facility. ■

Plans are in for new tunnel in Melbourne

The Victoria government in Australia has revealed the Melbourne Metro rail tunnel will run underneath the Yarra River, 11 m (36 ft) below the waterline.

Engineers on the multi-billion dollar project will use two tunnel boring machines (TBM), which will be buried underground.

The animation makes it look easy, but Transport Minister Jacinta Allen concedes tunneling under the Yarra will be a difficult job.

"Crossing the Yarra is one of the more complex parts of the Melbourne Metro rail project," Allen said.

Using the TBMs to cross the Yarra differs from what was proposed in the previous Metro Rail business case, which suggested an immersed tube tunnel or coffer dam construction, *9News.com.au* reported.

TBMs were seen as a less disruptive option than an immersed tube tunnel or coffer dam construction.

"Both of those approaches were seen as being more disruptive to the environment, more disruption to surrounding businesses," Allen said.

Pressure is on to get it right, with previous tunneling efforts under the Yarra proving problematic.

Construction of the Burnley Tunnel in 1999 resulted in serious leakage issues.

Public consultation is now underway. ■

Riyadh Metro: Includes 35 km (21 miles) of tunnels

(Continued from page 12)

more than 35 km (21 miles) of tunnels beneath the capital city.

Riyadh is one of the world's fastest-growing cities, with a population expected to increase 50 percent by 2035 to 7.5 million. The Riyadh Metro is part of a 25-year strategic plan prepared by the High Commission for the Development of Arriyadh to cater for this growth. When complete, the 176-km (109-mile), six-line driverless network will serve 400,000 passengers.

A global leader in the rail industry, Bechtel has successfully delivered some of the largest and most complex rail projects in the world, including the Channel Tunnel, High Speed 1, the San Francisco BART system and the Athens Metro. The company is currently providing project management services on Crossrail in London, UK, which is Europe's largest civil engineering project, and where (42 km) 26 miles of tunneling has just been completed on schedule. It is also working on the Rio de Janeiro Metro in Brazil and the Toronto-York Spadina Subway Extension in Canada. ■

RETC hosts more than 1,250 and 157 exhibitors in New Orleans, LA

Every two years, tunnelers and underground construction engineers, contractors, suppliers, designers and owners from around the world gather for the Rapid Excavation Tunneling Congress (RETC). In 2015, the conference was held in New Orleans, LA and more than 1,250 attendees were treated to 157 exhibitors and 113 technical presentations covering the breadth of the underground construction industry.

"We were very pleased with both the number of exhibits and the attendance, given that the event was just two weeks after the World Tunnel Congress (WTC) in Dubrovnik, Croatia. We received extremely positive feedback from those folks who attended both events. The lessons learned from the back-to-back events will help us when we present WTC2016 in April in San Francisco, CA," said SME Executive Director Dave Kanagy.

New Orleans

Hurricane Katrina was the costliest natural disaster in the United States history and was especially devastating to New Orleans, where 1,464 people were killed after the storm created 50 breaches in the drainage canal and levees. RETC attendees heard from two featured speakers about the recovery from the storm and a tour to Permanent Canal Closures and Pumps (PCCP) Project was available in conjunction with the conference.

For the past year, Traylor has been hard at work on the capstone of the PCCP Project for the U.S. Army Corps of Engineers. As part of PCCP Constructors, a

PCCP Project, a tour of the PCCP project was conducted in conjunction with RETC.

joint venture of Kiewit Louisiana Co., Traylor Bros. Inc., and the M.R. Pittman Group LLC, three permanent structures to block future hurricane storm surges to New Orleans from Lake Pontchartrain are being built. Not only must the new stations be designed to block surges from a 100-year storm, they must also take into account expected increases in the height of Lake Ponchartrain's water level during the next 50 years to account for the rising sea level caused by global warming and local subsidence. When the surge closures are operated during storms, the pumps will move 354 m^3/sec (12,500 cu ft/sec) of water from the 17th Street Canal into Lake Pontchartrain; 76 m^3/sec (2,700 cu ft/sec) from the Orleans Avenue Canal and 255 m^3/sec (9,000 cu ft/sec) from the London Ave. Canal. Temporary pumps and floodgates near the mouths of the three at-risk drainage canals (17th Street, Orleans Ave. and London Ave.) will stay in place until the team completes the permanent structures.

A major component of construction at each site is the pump station cofferdam. Unlike the closed cellular cofferdam cells Traylor has built in the past, these are being constructed with a relatively new open cell design developed by PND Engineering. The design utilizes fewer piles and is stable within a shorter diameter. The project is approximately 35 percent complete, with the preliminary site work and access roads completed. The team has also begun construction of the concrete structures. Project completion is scheduled for Sept. 27, 2016.

Angela DeSoto Duncan was the opening luncheon speaker. She is currently self-employed following a 24-year career with the Corps of Engineers and three-year career at Tetra Tech where she led nation-wide, multi-disciplinary teams of engineers, scientists and support staff for federal, state and local government clients. With the Corps, she was chief of a multidisciplinary branch responsible for the budget oversight, scheduling, cost estimating, design, real estate acquisition and environmental compliance documentation of the Hurricane Protection Offices' (HPO) five-year, fully funded, $7-billion Hurricane and Storm Damage Risk Reduction System (HSDRRS) program for the metropolitan New Orleans area. The HSDRRS program includes approximately 50 construction contracts consisting of levees, floodwalls, sector gates, lift gates, flood control structures, pump station rehabilitation, control houses and urban drainage projects.

The RETC dinner featured a presentation from Lt. General Russel Honoré, USA (Ret.) that was sponsored by The Laborers' International Union of North America & Schiavone Construction Co., LLC.

Lt. General Honoré arrived in a Hurricane Katrina-battered New Orleans in 2005 and saved a city by taking swift charge of military relief efforts. Drawing on his 37 years of military experience, Gen. Honoré now brings his bold, no-nonsense leadership approach to businesses and organizations to help better prepare them for the challenges of the future. He addresses how the public and private sector can solve a broad array of issues — from jobs and energy to healthcare and technology — by emphasizing innovation, risk assessment and social entrepreneurship.

RETC exhibits

As managers of RETC and the North American Tunneling (NAT) Conference (held in off years from RETC), SME had a good sense of the needs of the tunneling community for this event. Because the conference had grown considerably since securing the hotel for this event, the exhibits and technical sessions were spread over multiple floors. Mike Rispin of Normet stated "I was a little worried about the two floors, but the traffic at our booth was excellent and we had quality conversations with many good people."

In 2016, the UCA of SME will manage the World Tunnel Congress in San Francisco, April 22-28. That event will bring the usual attendees from RETC and (NAT). Conference as well as international tunnelers from Europe, Asia and South America. As many as 2,500 attendees are expected with as many as 350 exhibit booths. WTC will be a one-time enhancement to the regularly scheduled NAT Conference, with the NAT Conference returning in 2018 to Washington, D.C.

Sessions

In addition to the top level speakers and vibrant exhibit floor, RETC always features the most comprehensive collection of technical sessions available, and the 2015 conference was no different. With 21 different tracks to choose from, there was something of interest for everyone. The following is a look at a few of the 106 technical sessions that were presented during the conference.

A complete collection of the proceedings, including a CD for the papers, is available from SME for $149 for members, $139 for student members and $189 for nonmembers. The proceedings can be ordered from SME online at www.smenet.org/store or by calling SME at 303-948-4225, 1-800-763-3132.

Support of excavation for Roosevelt Station: Successful partnering overcomes challenging construction change, by Indra Banerjee and Ed Shorey, CH2M Hill; Hani Habib, Case Foundation Co; Elizabeth Lenker, McMillen Jacobs Associates and Brad Cowles, Sound Transit.

The Roosevelt Station is one of the two intermediate box excavations on the N125 Contract of Central Puget Sound Regional Transit Authority's Northgate Link Extension Project in Seattle, WA.

During design, the owner and designer settled on secant piles and tie backs for support of excavation. After award of the contract, the contractor expressed concerns about lead times for material procurement for the secant piles and advised that they were looking at alternative support methods. The contractor proposed a slurry diaphragm system to address their schedule concerns and improve upon the leakage and surface flatness requirements of the contract.

This paper presented the cooperative process undertaken by the owner, designer, construction manager and contractor to integrate the contractor's concept into the design, identify and address potential concerns with the design change, proactively engage the city's staff to streamline the permit review process and successfully complete the installation of slurry diaphragm wall system. Issues and challenges that were encountered during development and execution of the slurry diaphragm wall work are identified along with the steps taken to mitigate them.

Continuing a legacy of large-diameter hard rock tunneling in Chicago — The Des Plaines inflow tunnel, by Cary Hirner, Faruk Oksuz, Brian Gettinger and Brian Glynn of Black & Veatch Corp. with Kevin Fitzpatrick and Carmen Scalise, Metropolitan Water Reclamation District of Greater Chicago.

The Metropolitan Water Reclamation District of Greater Chicago's Des Plaines inflow tunnel will provide direct conveyance of 317 m^3/sec (11,200 cu ft/sec) of water from the Des Plaines Tunnel System to the McCook Reservoir. The project will alleviate a bottleneck in the Tunnel and Reservoir Plan (TARP) system by creating a second major tunnel connection to the 38 GL (10-billion gal) McCook Reservoir. The 1.6-km (1-mile) long, 6.1-m (20-ft) diameter hard rock tunnel will include live connections to the existing Des Plaines Tunnel System and to the operating McCook Reservoir as well as a gate shaft and an energy dissipation structure in the reservoir with low clearance crossings.

PPP mode for procurement of Lines 2 and 4 of Lima Metro, by Andrea Lavagno and Nicola Ruga, Geodata Engineering and Christy García Godos Naveda, Proinversión presented the paper about the new rail lines in Perus Lima Metro.

The new (and first entirely underground) lines 2 and 4 of the Metro Lima network represent a huge challenge in Peruvian infrastructure standards, even if the country is strongly committed to the public-private partnership (PPP) promoted by its pro-business organism Proinversión. With a U.S. $6.5-billion design build finance operate transfer-type contract, co-financed by Peruvian state, the project involves 35 stations and 35 km (21 miles) of fully UTO underground lines, to be drilled mainly by tunnel boring machines in a country with little or no experience in urban tunneling. The concession process was accomplished successfully in an outstanding 20-month period, from the consultancy assignment to the signing of the concession contract.

Challenges and methods utilized to excavate rock for an escalator incline through a luxury high-rise building in Manhattan, by Adam Smith and Anisa Dhimarko, Skanska USA Civil Northeast and James Collins, AECOM.

As part of the ongoing 2nd Avenue Subway extension program MTA Capital Construction (MTACC) contracted with Skanska/Traylor Joint Venture (STJV) to perform mining and structural concrete work for the 86th St. Station. One of the key components, as well as one of the highest risk pieces of work on the 86th St. Station contract, was to excavate rock through an existing luxury high-rise apartment building to make way for the escalator entrance. This work required temporary supporting the building to allow for the removal and subsequent replacement of main support columns that interfered with the future escalators. The authors discussed the successful engineering, planning and execution phases of this critical aspect of the excavation and underpinning of the high rise building.

Ground freezing for tunnel cross passages: First application in North America by David M. Mueller, Joseph A. Sopko and Robert Chamberland, Moretrench American Corp. and Roger B. Storry, Bouygues Travaux Publics.

Ground freezing was used for the first time in North America to freeze two 2.8 m (9 ft) diameter cross passages for the Port of Miami Tunnel. While ground freezing has been used for similar construction in Europe and Asia, this was the first application in North America. This project was complicated by the extremely porous subsea soils. To reduce the permeability of these soils and rock, an initial grouting program was implemented from the ground and channel surfaces.

Two rows of horizontal freeze pipes were drilled and installed to form the frozen cylinders for excavation support and ground water control for cross passage construction. The refrigeration system used to circulate the cooling medium was located at the ground surface and supplied to the cross passages via supply and return manifolds and a specially designed pumping system.

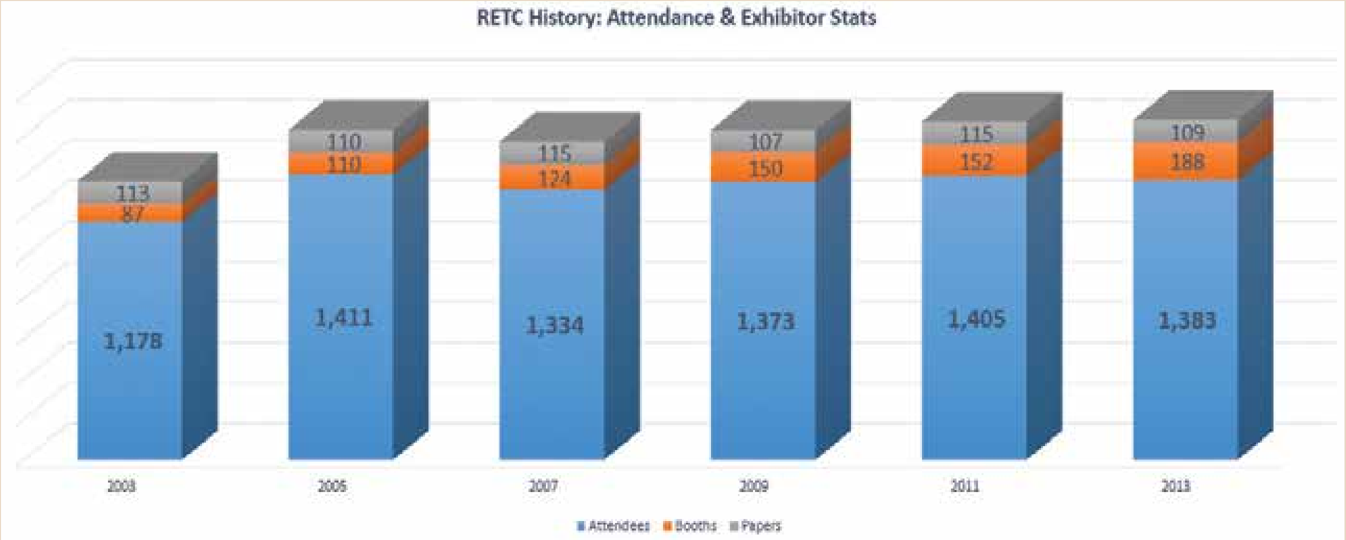
An extensive system of instrumentation was installed to monitor ground temperatures, soil and rock water pressures, coolant flow rates and pressures and process information from the refrigeration plants.

This paper discussed the grouting approach, freezing system drilling and installation; freeze monitoring and the excavation and completion process of a very successful project. Guidelines and recommendations for frozen cross passage construction are summarized.

Delivery of Crossrail Western Tunnels by Andy Alder and Dan Callaghan, CH2M Hill.

The Crossrail Project is building a new railway for London and the south-east of England, and is Europe's largest construction project. The construction of Crossrail has been split into a number of contracts, each tasked with delivering a section of the project. This paper specifically reviews the works undertaken on the C300/410 Western Tunnels contract, which involved the construction of

RETC has grown in the past decade to become a must-attend event for the tunneling industry.



6.8 km (4 miles) of twin-bore running tunnel constructed with a tunnel boring machine (TBM), and nearly 2 km (1 mile) of shotcrete-lined (SCL) tunnels.

When the project is complete the Crossrail trains will run more than 122 km (75 miles) of railway, running east-west below central London and connecting to suburban areas to the west and east of London. 21 km (13 miles) of the Crossrail route are being constructed underground and eight of the new stations are also being built underground.

The population of London is forecast to grow significantly. And to support this, the objectives of the Crossrail project are:

- To relieve congestion on the existing London Underground network, particularly the Central Line.
- To provide an additional 10 percent capacity to London's rail-based public transport system.
- To reduce journey times for people commuting into, and

across, London.

- To provide improved connections to Heathrow Airport, the West End and the business districts of the City and Canary Wharf.
- To support regeneration and connect to areas designated for additional housing provision.

Crossrail is Europe's largest construction project, with a funding envelope of £14.8 billion.

Seattle Fire Department's approach to tunnel rescue, by Frank Brennan, Seattle Fire Department.

For more than a decade, the Seattle Fire Department has successfully partnered with other public agencies, labor organizations and private contractors to develop an emergency response structure tailored to the specific conditions of the various tunneling and underground projects in Seattle, WA. This cooperative process has allowed the agency to develop a model and build a system for effective delivery of fire, rescue and emergency medical services into the underground environment that shares the burden of providing such resource intensive services. This paper outlined the process the Seattle Fire Department undertook to establish those relationships as well as the roles of its partners, development of its emergency response model and the supporting training program.

Tale of two cities — Subaqueous tunneling in London and New York City, 1879 to 1910, by Vincent Tirolo Jr., Arup.

Subaqueous shield tunnel construction began in London in 1828 when construction of Marc and Isambard Brunel's Thames Tunnel began. In London, Peter Barlow, James Henry Greathead, Benjamin Baker and Charles Jacobs developed tunneling practice to include circular shields, hydraulic jacks, cast iron liners and compressed air. In New York City in 1879, DeWitt Clinton Haskins attempted to cross the Hudson River using compressed air but without a shield.

A blow in 1880 caused 20 sandhog fatalities. Mining continued, but the work was abandoned in 1888 for lack of funds.

In London, Barlow and Greathead had successfully mined the 2.178 m (7 ft) diameter Tower Tunnel under the Thames using a circular shield, propelled by screw jacks reacting against a cast iron segmental initial lining. In 1889, Austin Corbin, president of the LIRR, invited Charles M. Jacobs of London to New York. In 1890, work resumed on the Hudson River when S. Pearson & Son of London assumed the construction contract. Sir Ernest Moir designed the shield for this work and introduced the first medical lock.

These events started the collaborative association of the tunneling engineering in both London and New York that would last more than 30 years and culminate with the completion of the Pennsylvania Railroad Tunnels under the Hudson and East Rivers in 1910. Concurrent with this mining collaboration, Werner von Siemens in Germany, Frank J. Sprague in the United States and others were developing electric traction systems into reliable systems that would make subaqueous railway tunnels possible.

WTC 2016

The UCA of SME will host the ITA-AITES World Tunnel Congress, WTC2016, April 22-28 at the Moscone Center in San Francisco, CA.

It will be the must-attend event of the year. WTC is the leading international conference each year. When it comes to the United States in 2016, it will feature as many as 600 technical presentations and 250 exhibitors. Between 2,500 and 3,000 people are expected to attend the conference designed especially for tunnelers representing owners, contractors, engineers and suppliers.

More information about WTC can be found at the conference website at www.wtc2016.us. ■

San Francisco to host ITA World Tunnel Congress 2016

by Harvey Parker and Amanda Elioff

The International Tunnelling and Underground Space Association (ITA) is a nonprofit organization that represents all aspects of the tunneling and underground space industry worldwide. Next year, the ITA will be holding its annual World Tunnel Congress (WTC) in San Francisco, CA, April 22-28, 2016. The ITA's mission is to be the leading international organization advancing the entire industry and promoting the use of tunnels and underground space through knowledge-sharing and application of technology. This article updates a series of articles about the ITA prepared in 2007 by Harvey Parker, former president of the ITA, in anticipation of the next WTC in San Francisco.

ITA accomplishes its goals through a range of activities that includes organizing conferences, workshops and meetings, working group and committee studies, training, experiments and other activities. ITA is also involved in the publication of proceedings, reports, and guideline documents as well as facilitating interaction among its membership and with sister organizations and decision makers. ITA currently includes 73 member nations and several hundred affiliate members, including 15 prime sponsors and 63 supporters. ITA's membership is comprised of member nations as well as sponsors and affiliate members.

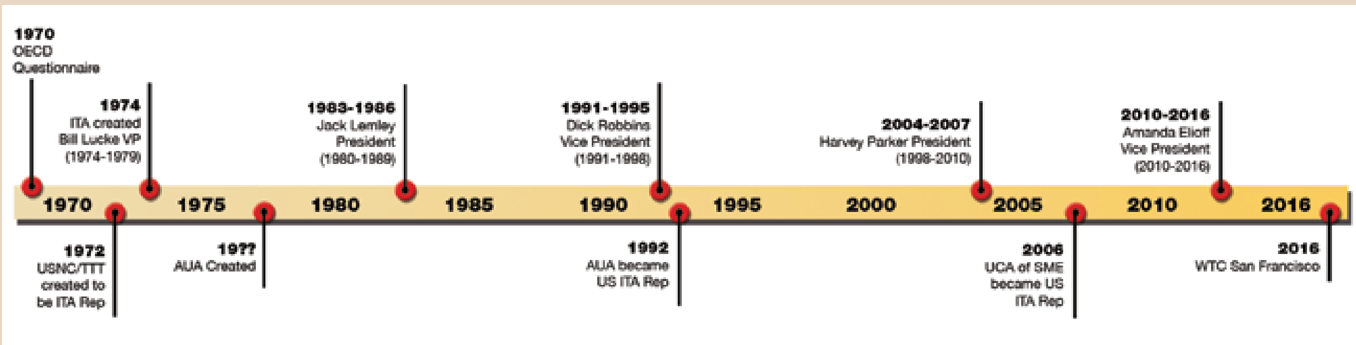
The United States has had a prominent role in ITA since its 1974 inception, when it was formed as a result of a worldwide survey conducted in the early 1970s by the Organization for Economic Cooperation and Developmentt (OECD). Bill Lucke, from the U.S., who was in charge of tunnels for the U.S. Federal Railroad Administration, was a member of the organizing committee that created ITA and became a vice president of ITA. Jack Lemley served as president of ITA from 1983 to 1986. Dick Robbins was active in ITA and served for many years as a member of the ITA's Executive Council and as first vice president. Harvey Parker served as president of ITA from 2004 to 2007. Amanda Elioff is currently serving on the executive council as a vice president. Over the years, the official U.S.

U.S. delegate Randy Essex attending ITA General Assembly.

representative has changed from the U.S. National Committee on Tunneling Technology (U.S.NC/

Figure 1

Timeline of U.S. involvement in ITA.



TT), to the American Underground Construction Association (AUA) to the current representative, the Underground Construction Association of SME (UCA of SME). A summary timeline of U.S. executive leadership and representation in ITA is presented in Fig. 1.

Moreover, there are many other individuals and companies from the United States that have contributed significantly to the activities and the success of ITA. There have been several active working group animateurs (essentially chairpersons) from the United States, and there have been significant contributions from many other individuals as well as companies from the U.S. Every known U.S. person contributing to ITA prior to 2007 was listed in Parker (**T&UC**, June 2007 and September 2007). Several U.S. engineers are currently serving ITA in a leadership role. In addition to Amanda Elioff, Henry Russell and Brian Fulcher are animateur and vice animateur, respectively, of ITA working groups. In addition to those who are elected by the ITA, there are numerous U.S. professionals currently contributing to ITA through UCA.

How is ITA organized?

ITA has something for everyone involved in the tunnel and underground space industry. ITA is an organization of member nations with a wide-ranging geographic representation throughout the world. The ITA Secretariat is currently located on the university campus of L'Ecole Polytechnique Fédérale de Lausanne (EPFL) in Lausanne, Switzerland. Each member nation is represented by one organization. The UCA of SME is the official organization representing the United States. SME Executive Director Dave Kanagy and Tim Reagan, SME director of operations, are providing SME oversight to the U.S. activities

Table 1

Diversity of members of ITA and UCA.

- Owners, public and private.
- Owners of engineering agencies.
- Private and governmental planners.
- Engineering designers & consultants.
- Academics and researchers.
- Heavy construction contractors.
- Specialty contractors and consultants, such as microtunnelling or shotcrete or freezing contractors.
- Material and equipment suppliers.
- Lawyers and politicians.
- Economists and financiers.
- Emergency response personnel.
- Mine owners and mining operators.

with ITA. Randy Essex is the official delegate from the U.S. to the ITA's General Assembly, the ITA body that meets annually at the ITA's World Tunnel Congress.

In Canada and Mexico, the comparable organizations are the Tunnelling Association of Canada and the Asociación Mexicana de Ingeniería de Túneles y Obras Subterráneas. It is estimated that the combined network of ITA extends through all member nations to some 20,000 people. The individuals participating in ITA are very diverse, coming from all walks of life, backgrounds, industries and professions. This diversity of professional culture is shown in Table 1.

Figure 2

ITA working group publication.

In addition to the main member nations, ITA also has 300 corporate or individual affiliate members. Of these, the U.S. has 14 corporate members and several individual members. There are also two levels of sponsorship, the prime sponsor level and supporter level. The U.S. has one prime sponsor, The Robbins Company, and five supporters: Harvey Parker & Associates, Inc., ARUP, Aldea Services, LLC, Parsons

Brinckerhoff, and W.R. Grace.

ITA organizes and sponsors numerous meetings, workshops and training sessions all over the world each year on the full range of topics associated with tunnels and underground space. During annual meetings, and now between meetings due to email and other forms of communication, ITA's working groups meet and develop reports and guidelines for their fields of expertise (Table 2). Working groups are composed of individuals designated by the member nations as well as volunteers from the industry at large. Table 2 is a list of the currently active working groups and Fig. 2 illustrates the cover page of a recent ITA Working Group publication.

Recently, several committees have been formed to address issues of importance on a different level than what can be accomplished by working groups. Committees are composed of corporations and organizations interested in the particular topic. Unlike working group members, most corporate committee members pay a fee for their membership. The committees are:

Table 2

ITA Working Groups and U.S. representatives.

Working Group
Young Members Group
WG – 2 Research
WG – 3 Contractual Practices
WG – 5 Health and Safety in Works
WG – 6 Maintenance and Repair of Underground Structures
WG – 9 Seismic Effects
WG – 11 Immersed and Floating Tunnels
WG – 12 Sprayed Concrete
WG – 14 Mechanized Tunnelling
WG – 15 Underground and Environment
WG – 17 Long Tunnels at Depth
WG – 19 Conventional Tunnelling
WG – 20 Urban Problems - Underground Solutions
WG – 21 Life Cycle Asset Management
*Designated representative

- Committee on Education and Training (ITA-CET) organizes and conducts training courses and

Table 3

Publication of proceedings, reports and documents.

Publications available from publishers.	
•	Proceedings of all World Tunnel Congresses.
•	Scientific Journal: Tunnels & Underground Space Technology (TUST) available to all ITA Members.
Electronic newsletter "ita@news"	
•	Covers activities of member nations, prime sponsors and supporters and relevant news regarding tunneling and underground space, sent every two months.
Publications and presentations available from ITA Web site www.ita-aites.org	
•	Working group and committee reports (published in TUST but the individual reports are available for free on the ITA Web site, www.ita-aites.org).
Position papers	
•	Papers and presentations from all ITA training sessions.
•	Selected workshop and conference proceedings (papers and presentations), CD-ROM of all formal ITA publications from complete 30-year history.

and training to help with financing of training worldwide. In addition, ITA has established a university network that is nurtured, proactive, extended and actively promoted, including the endorsement of university masters courses.

- ITA COSUF is the Centre of Excellence for world-wide exchange of information and know-how regarding safety and security of underground facilities in operation. The committee's scope concerns the operational safety in tunnels and other underground facilities as well as security. ITA COSUF conducts workshops, has published more than 50 documents and conducts award ceremonies.
- Committee on Underground Space (CUS) promotes the use of underground space to help cities cope with urban challenges including shortage of space above ground, sustainable development and resilience. CUS forms links with relevant decision makers and sister organizations such as the United Nations (an NGO with the UN since 1987), the European Union, World Bank and Development Banks worldwide, as well as owners and planners of tunnels and underground space.

ITA has also developed a close relationship with the industry through the most recently created committee, ITATECH, which is a collective group of all prime sponsors and ITA supporters. ITA TECH has established many activity groups which work on summarizing and expanding the state of practice of various tunneling tasks.

Last year, the ITA established a young member forum. The aim of the group is to:

- Provide a technical networking platform within ITA for young professionals and students.
- Bridge the gap between generations and to network across all experience levels in the industry.
- To look after the next generation of tunnelling professionals and to pass on

the aims and ideals of the ITA.

This year, the ITA will also host the International Tunnelling Awards. With the growth of infrastructure needs and requirements for better use of space and resources, the development of underground options has often provided excellent solutions to these challenges. As part of this endeavor, the ITA has taken the initiative to launch its own dedicated Tunnelling Awards to identify outstanding achievements in the field of tunneling and underground space use, and to provide international recognition to these remarkable contributions. The awards ceremonies will be held in different locations worldwide, with the first annual event (Fig. 3) to be held at the Hagerbach Test Facility near Zurich in Switzerland on Nov. 19, 2015.

Figure 3

ITA awards ceremony to be held at the Hagerbach Test Facility near Zurich, Switzerland.

ITA continually publishes the results of its activities as outlined in Table 3. It publishes all of its information for the benefit of its members and the public. An enormous amount of valuable information has been published and archived by ITA. Essentially, all the available documents published in the last 40-plus years are available on the ITA website free of charge.

Finally, ITA is a forum for the exchange of information among its members and for informing official bodies, such as the United Nations, The European Union, governments, owners and planners of the public at large, about, benefits of tunnels and underground space.

U.S. participation in ITA strengthens UCA

All members of the UCA of SME may participate in ITA activities, and participation in ITA activities benefits both ITA and UCA. UCA designates one person to be the official delegate to each working group. However, one can express interest in an ITA working group and become a corresponding member. As a corresponding member, individuals can contribute to working group meetings and communications. Working groups hold a meeting during every WTC. Travel to ITA conferences is good because of the friendships made during these meetings, and technology transfer is easier face-to-face. Professional activities and technology transfer do involve work and sometimes travel. However, one can also contribute to UCA-ITA activities by email and/or FTP sites administered by each working group.

U.S. hosting of annual ITA World Tunnel Congresses

To date, the U.S. has hosted several executive council meetings, two meetings of the annual ITA World WTC and is the host of the next WTC in San Francisco. The first U.S. WTC was held in 1979 in Atlanta, GA and the second in 1996 in Washington, DC. Although ITA had emphasized the environment since its beginning, the theme of the Washington, D.C. conference, sustainable development, was the first time an ITA conference highlighted this topic. The WTC2016 conference theme for San Francisco is "Uniting Our Industry." UCA is working very hard to organize and make this an extraordinary event for all in the industry.

Conclusion and challenge

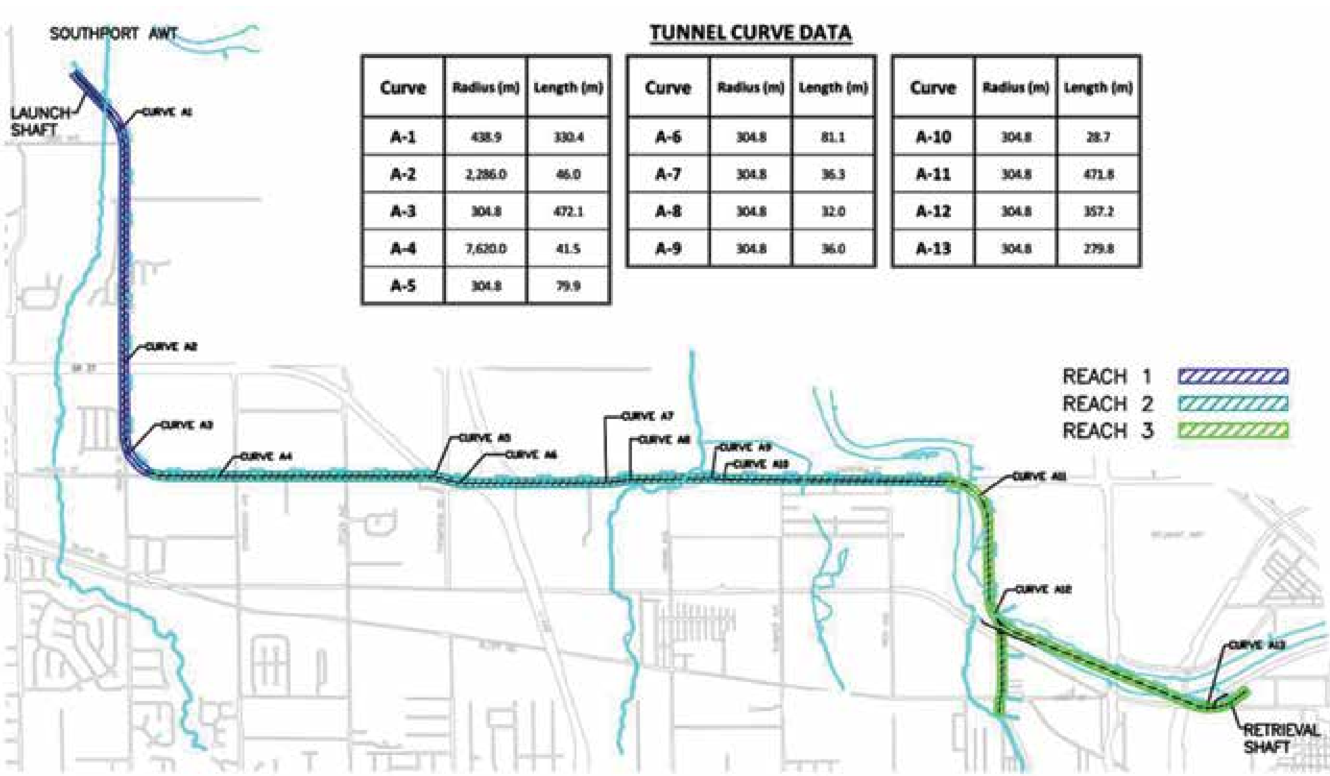
The U.S. is only one of the many countries to have strongly contributed to the success of ITA. However, the U.S. and, especially UCA members, can be proud because the U.S. has a wonderful heritage and legacy in the success of ITA, which should be built upon and continued by the UCA and its members. The authors recommend involvement by individuals and, companies. ITA is a great platform to demonstrate your successes and provides good marketing and networking opportunities. ITA also provides a special opportunity for young professionals. Join us in 2016 for the WTC in San Francisco. By joining and participating, you will reap the numerous advantages of being an active member of the "ITA Family." ■

FEATURE ARTICLE

TBM mining for the Deep Rock Tunnel Connector project

Figure 1

Overall alignment of the Indianapolis Deep Rock Tunnel Connector project.



Curve	Radius (m)	Length (m)
A-1	438.9	330.4
A-2	2,286.0	46.0
A-3	304.8	472.1
A-4	7,620.0	41.5
A-5	304.8	79.9
A-6	304.8	81.1
A-7	304.8	36.3
A-8	304.8	32.0
A-9	304.8	36.0
A-10	304.8	28.7
A-11	304.8	471.8
A-12	304.8	357.2
A-13	304.8	279.8

The Deep Rock Tunnel Connector project is being constructed by the S-K JV, a joint venture between the J.F. Shea Construction and the Kiewit Infrastructure Co. As bid, it was a $179-million dollar project being built to address combined sewer overflows into the White River in the city of Indianapolis. Currently, the project is on schedule and budget for excavating and lining of the tunnel with completion in May of 2017.

Michael Stolkin, Eric Haacke and Mark Guay

Michael Stolkin and Eric Haacke, member UCA of SME, are engineer and project engineer, J.F. Shea Construction respectively, and **Mark Guay** is resident engineer, AECOM, email eric.haacke@jfshea.com.

Geology

The Deep Rock Tunnel Connector project (DRTC) is located in the city of Indianapolis in Marion County, IN. Marion County is located between two regional bedrock structures, the Kankakee Arch to the northeast and the Illinois Basin to the southwest. Devonian and Silurian carbonate rock underlie most of Indianapolis and the White River valleys where the DRTC is located. New Albany Formation shale was encountered at elevations ranging from approximately 167 to 190 m (550 to 625 ft) along most of the DRTC alignment. Additional bedrock formations underlie the New Albany shale, including North Vernon Formation limestone and Vernon Fork and Geneva. The DRTC tunnel is excavated within the Vernon Fork Formation, the Geneva Formation, or a mixed face of both formations.

The bedrock within the tunnel zone exhibits vertical

Figure 2

Rebuild of TBM.

to subvertical, northern and eastern trending, very close to a widely spaced joint structure, with horizontal to subhorizontal bedding trends to the east. The rock is moderately strong to very strong. Cerchar Abrasiveness Index (CAI) testing was conducted and yielded a value range between 0.1 and 2.9. Approximately 56 percent of the data indicated very low to low abrasiveness, 31 percent had medium abrasiveness, and 3 percent exhibited high abrasiveness.

Safety

A typical shift begins with an all-hands safety meeting held at the surface before heading to the shaft and then underground. This is a free exchange of information between employees and supervision to speak about any safety related topics relevant to the work and discuss and remind all involved about concerns and issues. With few exceptions, the day shift safety meeting is attended by both the project manager and project superintendent, who have active speaking roles and are visibly engaged with the meeting. After the meeting is adjourned, the shift supervisor ensures that the tunnel system is safe for entry by conducting and reviewing a variety of gas readings such as oxygen percentage of the tunnel atmosphere, and carbon monoxide, nitrogen, hydrogen sulfide, etc. This tunnel is being excavated in rock that contains water with dissolved hydrogen sulfide gas, and also has areas that were identified with small oil seeps. Because of the possibility of gasses during excavation, the TBM was equipped with a gas detection system that monitored methane, hydrogen sulfide and oxygen. The methane detectors were interlocked with the tunnel boring machine (TBM) power system and would shut down the TBM power if gas concentrations at 10 percent of the LEL were identified.

Underground, the shifter is responsible for knowing the locations of all personnel along the tunnel alignment and the working heading. Communication phones are placed along the tunnel alignment as well as at all boosters and any permanent equipment set in the tunnel. To ensure all workers are aware of the startup of the conveyor system and the TBM, a klaxon and strobe light system was employed. If crew members are undertaking maintenance in the cutterhead, the head is locked out by the TBM operator who controls the only key, and thereafter is responsible for inspecting the head and ensuring it is clear of workers before returning to normal operating status.

Contractually, the project is under an owner controlled insurance program (OCIP) and to date has been viewed as being very successful, but not without plenty of involvement from the SK-JV from the level of labor through upper management.

Survey control and TBM guidance

Initial survey control for the starter tunnel was developed from a control dropped down the starter tunnel shaft and transferred to a variety of points along the alignment as the drill-and-blast development of the starter tunnel progressed. Before setting up the TBM, an accurate survey in the starter tunnel was undertaken and again a variety of points set for the TBM to back sight on. The network of points installed was developed using a north seeking gyro with accuracy to one second.

The north seeking gyro (DMT Gyro Mat 2000) was utilized along the tunnel alignment to establish control lines and re-adjust control that the TBM guidance system back-sighted on. The interval of gyro measurements taken was every fifth traverse leg, which was sufficient to maintain horizontal tolerances. Horizontal tolerances along the tunnel right of way were plus/minus 30.48 cm (12 in.), with tighter tolerances as the tunnel approached various shafts along the route. Three utility shafts raise bored to 3.05 m (10 ft) in diameter were completed along the tunnel after the TBM mined beyond their locations, and with either the completed raise bore or the pilot hole, the opportunity to tie the tunnel survey into surface control was also undertaken and to verify the PPS Guidance System being used on the TBM. With the use of the north seeking gyro, the availability of drop holes and shafts along the alignment, and experienced personnel, tunnel alignment never became problematic.

TBM

The TBM used on the DRTC, Robbins Model 203–205, was originally constructed by Robbins in 1974 and has been used on a variety of projects by contractors, including J.F. Shea, since then. The TBM and trailing gear have been altered over the years to accommodate the tunnel contracts and keep pace with technology. The DRTC project is no exception to this. Below is a list of the prior projects the TBM has completed.

- MTA — 63rd Street Tunnel project, New York City (completed 1979) 6.1 m (20 ft) diameter.
- Montreal, Canada — Sewer tunnel (completed 1986) 6.1 m (20 ft) diameter.
- NYCDEP — Brooklyn Water tunnel (completed 1986) 6.71 m (22 ft) diameter.
- Fall River, MA — Fall River CSO tunnel (completed 2003) 6.71 m (22 ft) diameter.
- MTA — 2nd Avenue Subway C-26002, NY (completed 2011), 6.71 m (22 ft) diameter.

Prior to bidding and after award, there were a number of concerns to deal with when planning to refurbish the TBM. In order to maximize production geology described in the bid, documents were further reviewed. Geology was anticipated to be very favorable in achieving high production rates. Another item given consideration was the 762-m (2,500-ft) long Pleasant Run tunnel spur off of the main DRTC alignment, as shown in Fig. 1. This would require backing out the TBM

Figure 3

Robbins cutterhead.

Figure 4

TBM trailing gear.

to continue along the main tunnel alignment. And as a follow on to expected good geology and high excavation rates, a conveyor system with high capacity would also be needed.

In the process of refurbishing the TBM (Fig. 2), a new cutterhead was designed in conjunction with Robbins and fabricated by Robbins. It made use of 48.26 cm (19 in.) back loading cutters, had a flat face, no face buckets, and oversize peripheral buckets. This enabled good cutting of the rock, and with the space between the cutter head face and rock face, plenty of room for material to fall with minimal regrinding. The 48.26 cm (19 in.) cutters would also offer the advantage of needing fewer cutter changes while being able to withstand the high loads the machine would be capable of. Also incorporated into the design was the likely need to disassemble the cutterhead in order to back out the TBM. To further save time, the head was designed in three main sections that were bolted to one another. The main center section was circular and was bolted onto the cutterhead support and bearing assembly. Onto this the two outer portions were attached and secured by bolted connections. As hoped, the cutterhead performed exceptionally well with little regrind, offered good internal access and cleaned material away from invert exceptionally well.

Figure 5

Rock support at Pleasant Run.

To minimize production downtime, power to the cutterhead required attention as well, so the drive system was evaluated, replaced and upgraded. Clutch packs that were previously used were eliminated. Using the VFD system made doing away with the air clutches a viable option as they were viewed as failure prone from other work experiences. On a practical note, the cutterhead speed was limited to a maximum of 8 rpm so that gauge cutter bearing life could be maximized. With air clutches eliminated from the driveline, torque limiters were inserted to provide a level of safety. These were viewed as especially robust, having few moving parts and only needed if the cutterhead should lock up unexpectedly or a problem with the pinion and bull gear meshing arose. They were set at a specific loading and would come into play should loadings be exceeded and thereby offer a level of safety in the drive system before damage could occur. So, power to the cutterhead began with VFDs powering each motor, and thereafter through the torque limiter, followed by the planetary reducers, and then the pinion/bull gear which is directly attached to the cutterhead bearing assembly.

A well-designed cutterhead, as shown in Fig. 3, and geology along with the 48.26-cm (19-in.) cutters resulted in very few cutter changes over the length of the excavation. The drive system, from the VFDs to the electrical motors and associated driveline components were problem-free, as planned. These small planning details and execution proved to be quite beneficial in allowing S-K JV to take advantage of the geology with high production rates in areas of the tunnel alignment that were not impacted by grouting downtime.

General TBM overview

The main bearing and seal assembly consisted of a high-capacity, asymmetrical, tapered roller bearing, 35.05 cm (138 in.) outside diameter, ring gear and inner/outer seal assemblies. The main drive consists of water-cooled electric motors with planetary gear reducers to drive a common internal hardened ring gear.

Cutterhead horsepower and drive system details:

- Cutterhead torque: 3,261,741 Nm (2,405,737 ft-lbs).
- Cutterhead rotation speed: 0 to 8 rpm.
- Cutterhead reversibility: The cutterhead has the ability to be reversed.
- Machine thrust: 1,356,241 kg (2,990,000 lbs).
- Thrust per cutter: 29,483 kg (65,000 lbs) per cutter.
- Total weight of TBM: 408,233 kg (900,000 lbs).
- The machine has a total of 16 trailing gear decks, as shown in Fig. 4.

After a year of hard work, the final loads of equipment were shipped to Indianapolis for assembly in the starter tunnel. The final assembly of the TBM took less than three months and mining began in March 2013.

Figure 6

Conveyor system on the surface.

Probe drilling and grouting

Geology report characterizing water inflows along the tunnel alignment indicated that most of the water would be expected in the second half of the drive; with the first half relatively dry. Contract bid documents also mandated grouting when water inflows through a probe hole exceeded 378 L/min (100 gpm) and, if inflows exceeded 189 L/min (50 gpm), the engineer to be notified and direction to be provided as to whether or not to grout. Along with requirements for grouting, the design also called for lengths of the tunnel to be unlined, but still a strict water inflow requirement had to be adhered to.

A ring-mounted probe drill was mounted after the roof drills on the drilling platform. The drills were designed to probe in line and articulated to drill multiple patterns. Probe holes were drilled along the entire tunnel alignment. The holes were drilled utilizing two Boart Longyear HD150 hydraulic drills.

A Hany high shear colloidal mixer of approximately 19820 L/h (5,236 gph) capacity was used. After setting up the plant and header pipes, the grout material was mixed in accordance with the mix design. The standard mix started with a 4:1 water-cement ratio by weight. Refusal grouting was considered complete when the pressure gauge reached 6.89 bar (100 psi) over static water pressure. Secondary holes were drilled to ensure that the water has been shut off in the probe zone.

Ground control

While the cutterhead design stabilized the face, temporary ground control was achieved with a hydraulically activated roof shield and side support structures on each side of the machine. The roof support was equipped with support structures on each side of the machine. The roof support was equipped with cut outs in four locations to allow for rock bolt installation ground stabilization equipment. Omega expandable friction bolts supplied by Dwidag were installed to secure unstable rock, as shown in Fig. 5.

Two roof drill units on either side of the main beam allowed independent rock drilling simultaneous to TBM boring. The TBM was a shield machine that provided temporary support in unstable ground and maintained the integrity of the bore by keeping the roof and side supports extended against the tunnel surface until the ground support was installed. The entire shield extended 6.1 m (20 ft) and was slotted with opening extending 50.8 mm (2 in.) from the end of the shield towards the face approximately 127 mm (5 in.) wide to allow for the installation of ground support.

Muck handling

Excavated rock was removed with a horizontal and vertical conveyor system with more than 10,668 tunnel m (35,000 ft) on conveyer installed in the tunnel, another 76 m (250 ft) going up the shaft and the ability to store or let out 609 m (2,000 ft) of conveyor from a surface-mounted storage unit. The belt was a 914-mm (36-in.) wide, three-ply belt with a 800 PIW rating and 3/16 in. wearing surface. At the shaft bottom, the loaded belt discharged onto a vertical bucket belt to be hauled up the shaft and deposited onto a stacking conveyor.

Power to the loaded horizontal belt was supplied through a series of boosters with 149-kW (200-hp) drive assemblies. The unloaded belt was powered by return boosters, again with 149-kW (200-hp) drives. The surface storage unit, as shown in Fig. 6, provided easy access to the belt for inspection, and allowed the belt to be loaded into the system without having to lower rolls of conveyor down into the shaft or starter tunnel. Splices were done by trained crews at the surface in a sheltered enclosure, and mechanical splices were kept to an absolute minimum, with mechanical splices replaced by vulcanized splices. A 37-kW (50-hp) electric motor that was excited by a small variable frequency drive was used to supply tension in the system at the storage unit, and again, with no moving parts other than the cable due to the use of the VFDs. Each drive assembly underground was powered by individual VFDs as well. Each drive was monitored at the surface by PLC systems tied into a fiberoptic cable and ethernet access was available from the surface as well. For the system startup and under loaded conditions, various parameters such as timing between boosters, ramp up speeds, belt speeds and motor loads, could be monitored and then altered from an office setting topside, allowing for changes to the system as the belt length increased.

The horizontal belt also had to overcome more than just the linear quantity of belt installed. As noted earlier, the tunnel also had five curves, two 90° curves with 304 m (1,000 ft) radii, and the remaining three at varying lengths and curve date. The horizontal belt carrying structure required the use of the self-aligning troughing rollers in curves to keep belt tensions within a managable range.

Mining

Mining production commenced at the southern end of the alignment, which is located at the Southport AWT facility and continued north to the intersection of South West Street and South White River Parkway East Drive. The north end of the DRTC segment is at the south end of the Fall Creek/White River (FCWR) tunnel project segment.

The 12.5-km (8-mile) tunnel was divided into three sections (in proper production sequence):

- Reach 1 - 2,920 m (9,579 ft).
- Reach 2 - 5,784 m (18,976 ft).
- Reach 3 - (US #3 to wye) 1,242 m (4,076 ft).
- Pleasant Run Extension - 709 m (2,326 ft).
- Reach 3 (wye to Retrieval Shaft) - 1,897 m (6,224 ft).

Once the Pleasant Run Extension was completed, utilities were removed and the TBM returned to the wye. Concurrently, TBM/belt maintenance was preformed, and preparations for the bulkhead were made. Once the bulkhead was installed, a concrete plug was placed to tunnel springline to provide adequate strength for the grippers. Once mining advanced past the wye section, the plug was removed by drill-and-blast methods and mining resumed to the retrieval shaft.

Using the aforementioned equipment and methods, the S-K JV team has made many achievements, including setting three production world records. These records are:

- Most feet mined in one day, 124.93 m (409.89 ft).
- Most feet mined in one week, 515.12 m (1,690.04 ft).
- Most feet mined in one month, 1,754.17 m (5,755.15 ft).

Conclusion

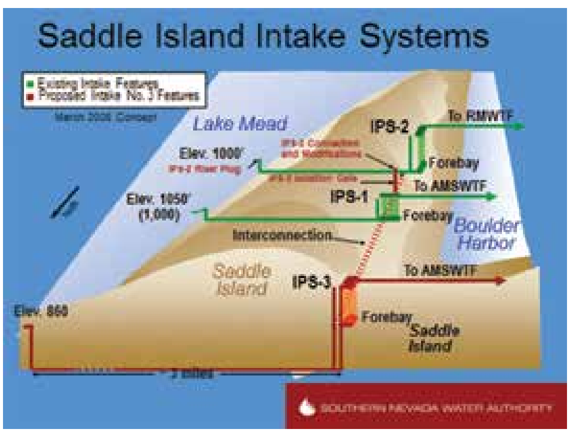
The methods used for this project have been performed countless times over the years. Every project encounters unexperienced situations, but by using proper planning, incorporating new technology with time-tested methods and experienced personnel, S-K JV has been able to able achieve three mining production world records and perform remarkably well at the Indianapolis Deep Rock Tunnel Connector project. ■

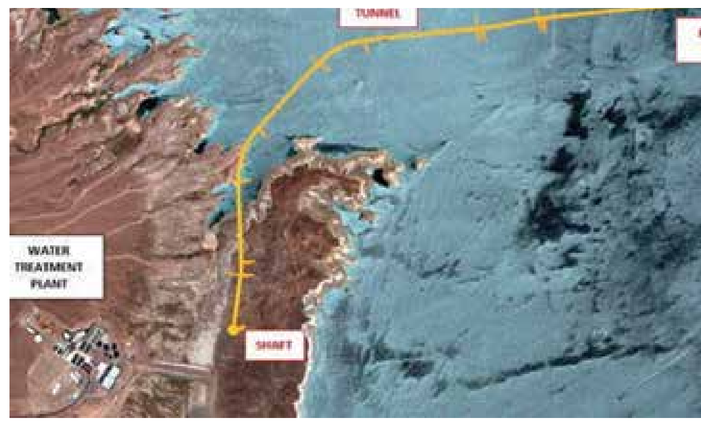
FEATURE ARTICLE

Lake Mead intake No. 3: TBM tunneling at high pressure

Figure 1

Project overview.





In response to the severe drought on the Colorado River basin and in order to preserve existing water capacity to the Las Vegas Valley, the Southern Nevada Water Authority contracted a new deep-water intake (Intake No. 3) located in Lake Mead. The current project (Contract No. 070F-01-C1) includes 5 km (3 miles) of tunnel with very difficult geological conditions and a 200-m (650-ft) deep shaft and marine works. This paper will present the current status of the design-build contract being constructed by Vegas Tunnel Constructors and the challenges and problems faced and the innovative solutions developed to handle the difficult conditions encountered during tunneling with up to 15 bars of pressure.

Jim Nickerson, Roberto Bono, Claudio Cimiotti and Erika Moonin

Jim Nickerson, Roberto Bono and Claudio Cimiotti, member UCA of SME, are project manager, chief engineer and senior tunnel engineer, Vegas Tunnel Constructors JV, respectively, and **Erika Moonin** is project manager, Southern Nevada Water Authority, email jnickerson@vtcjv.com.

Project background

The Las Vegas Valley receives the majority of its water from Lake Mead, which is located approximately 30 km (20 miles) east of the Las Vegas, NV metropolitan area. Due to the severe drought that has hit the southwest region of the United States, the water level in Lake Mead has receded from its high water level of 372 m (1,221 ft) above mean sea level (amsl) to a low of 330 m (1,076 ft) amsl in June 2015. Should the lake level continue to fall, at elevation 320 m (1,050 ft) amsl, the current water intakes will not be able to draw enough water to meet the needs of the local area. The risk of losing water capacity has prompted the construction of a new deeper intake. Not only is the new Intake No. 3 situated at a lower elevation in the lake at 262 m (860 ft) amsl, the new Intake No. 3 is also located to draw better quality (Fig. 1).

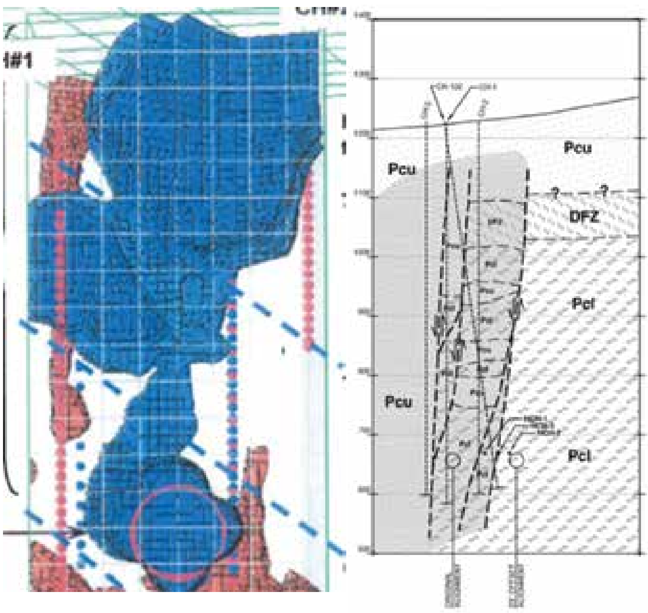
Project challenges

The project has had several difficult challenges to overcome:

- The work consisted of a 1.2 kt (1,300 st) structure constructed on a barge and lowered 100 m (330 ft) into Lake Mead anchored with 9,200 m^3 (12,200 cu yd) of tremie concrete.
- The drill-and-blast starter tunnel was impacted by three inflow events, resulting in a one-year project delay.
- One of the main challenges was selecting the tunnel boring machine (TBM) and excavating the tunnel with expected hydraulic head pressure of as much as 17 bar (16 bar was the highest pressure recorded during the drive), crossing faulted areas, low rock cover and the risk of tunnel instability

Figure 2

Tomography and geological condition.



due to direct connection with the lake.

- Extensive pre-excavation grouting with a constant head pressure ranging from 12 bar to 15 bar.
- Structural repair of the cutterhead in difficult hydrogeological conditions [water inflow of approx. 800 m^3/hr (4,000 gpm)].
- Complete repair of the cascade sealing system for the main bearing and two replacements of the pinion bearings.
- The TBM approach to the intake structure.

Shaft, cavern and starter tunnel

The Intake No. 3 project consists of a concrete-lined shaft that is 183 m (650 ft) deep with an internal diameter of 10 m (30 ft). The shaft intersects a cavern that is 61 m (200 ft) long and was designed to accommodate the assembly of the TBM. The starter tunnel is 120 m (360 ft) long to allow the TBM to start mining in closed mode configuration and to house the belt storage unit when the TBM operates in open mode.

The construction of the shaft started in August 2008 and ended in May 2010. The shaft and cavern were excavated by conventional drill and blast method, 3 m (10 ft) per round and was concrete-lined as the shaft was excavated.

Three extensive grouting campaigns were performed to control the high water inflows encountered during the excavation of the shaft.

Mining work on the original starter tunnel began in February 2010 and, after 47 m (150 ft) of excavation, a large inflow occurred, approximately 5,000 m^3 (6,600 cu yd) of material filled the starter tunnel and the cavern. Drilling equipment for ground investigation was then mobilized to understand the geological conditions and to evaluate the need of grouting from the surface.

After a month of investigation and grouting, the dewatering of the shaft and cavern began. The water was pumped at slow increments to check the condition of the concrete lining and to closely monitor the water inflow coming from the starter tunnel. After the dewatering was completed, work began, which including removing the buried equipment and reestablishing electricity and ventilation.

On Oct. 26, 2010, excavation to reinstate the starter tunnel to its previous face station began. On Oct. 27, while excavating the top bench, there was a second in-rush of material. A bulkhead was installed to contain the flowing material.

Between Oct. 27 and Dec. 31, drilling began on additional core holes on surface and underground to look for an alternate alignment. Concurrent work resumed with drilling drainage and grout holes in the original alignment.

On Dec. 31, a third inflow occurred during the drilling of one of the holes. In January 2011, the decision for a new alignment at 23° east of the original tunnel axis was taken.

The old starter tunnel was abandoned, the new, 120-m (360-ft) long, starter tunnel was excavated by drill-and-blast utilizing a canopy pipe system to ensure the stability of the tunnel. The new starter tunnel was successfully completed at the end of July 2011.

TBM tunnel drive

TBM description. The TBM used to excavate the 4.5 km (3 miles) of the intake tunnel was a Herrenknecht hybrid machine. It was a prototype with the capability of operating either in open or closed mode, depending on the hydrogeological conditions of the rock masses encountered.

Open mode operation consisted of excavating the ground without any face support, evacuating the excavated material via a 18-m (60-ft) long horizontal screw conveyor. This fed a system of belts that ran along the TBM trailing gear, then on a continuous conveyor along the lined tunnel and terminated at the bottom of the shaft where the muck was discharged into two buckets. Each bucket had a capacity of 15 m^3 (20 cu yd) and ran vertically up the 180-m (600-ft) shaft to the surface (Figs. 3a and 3b).

Once on the surface, an overland conveyor was utilized to take the muck to the designated disposal area on the site.

In closed mode the TBM operates like a slurry machine. Mining was performed by applying a support pressure at the face. This mode was used in order to help stabilize the ground and to reduce the risk of tunnel flooding in the case of encountering highly permeable rock masses or direct connection with Lake Mead.

The machine was designed to withstand a maximum hydraulic head pressure of 17 bar and operate at 15 bar. The cutterhead was equipped with 48 cutters, 43 cm (17 in.) in diameter excavating a tunnel diameter of 7.22 m (23.7 ft). The cutterhead required 2,800 kW and the total installed power was 5,750 kW. The breakout torque was 10 MNm and the thrust ranged from 70,000 kN to 100,000 kN.

All of the equipment necessary to operate the TBM was installed on 15 gantries with a total length of 185 m (607 ft) and a total weight of 1.5 kt (1,650 st).

Among many special features, the TBM was equipped to handle high water pressure and inflows. The machine was also equipped with three drill rigs in order to perform either geological investigation (probing and coring) or pre-excavation ground treatment to reduce the permeability and/or increased stability of the rock masses ahead of and around the TBM. Drilling could be carried out through the cutterhead or the shield with a pattern of holes (14 peripheral through the shield; 20 through the cutterhead) characterized by different inclinations (0°, 3.5° and 7°).

Hyperbaric interventions. Face interventions for maintenance occurred in atmospheric conditions. However, in the event maintenance was required during closed mode operation, the TBM was equipped and the personnel was trained for hyperbaric interventions. The equipment to perform saturation dives at high pressure included:

- 1,200 gas cylinders (heliox), stored on site.
- Four tube trailers (135,000 cf each), stored off site.
- Saturation control van.
- Special decompression chamber/medical lock.
- Transport shuttle.

Reach 1: Lower and upper plate formation

Geology STA 4+79 to STA 31+81. The lower plate was characterized by a mix of amphibolite gneiss with presence of quartz-feldspar bedding. In the detachment fault, we encountered soft, highly fractured and brecciated clay gauge material.

The upper plate was characterized by a heterogeneous assemblage of crystalline metamorphic rock: predominantly, quartz-feldspar, granite, pegmatite and mica schist.

Drive. The TBM was launched on Dec. 27, 2011. Based on the expected geological conditions of the Saddle Island

Figure 3a

Open mode configuration.

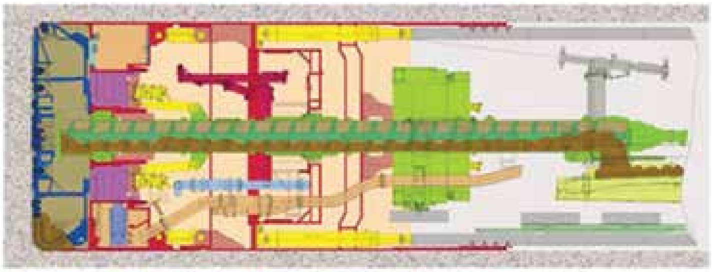


Figure 3b

Closed mode configuration.

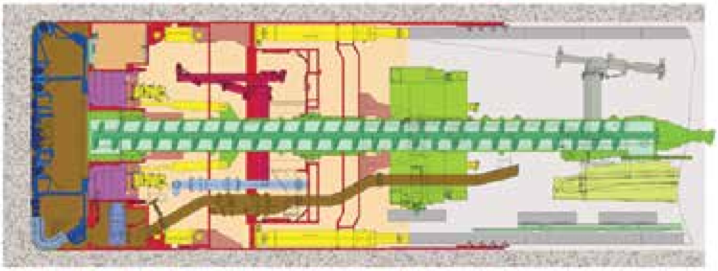


Figure 4

Grouting campaigns – grout patterns.

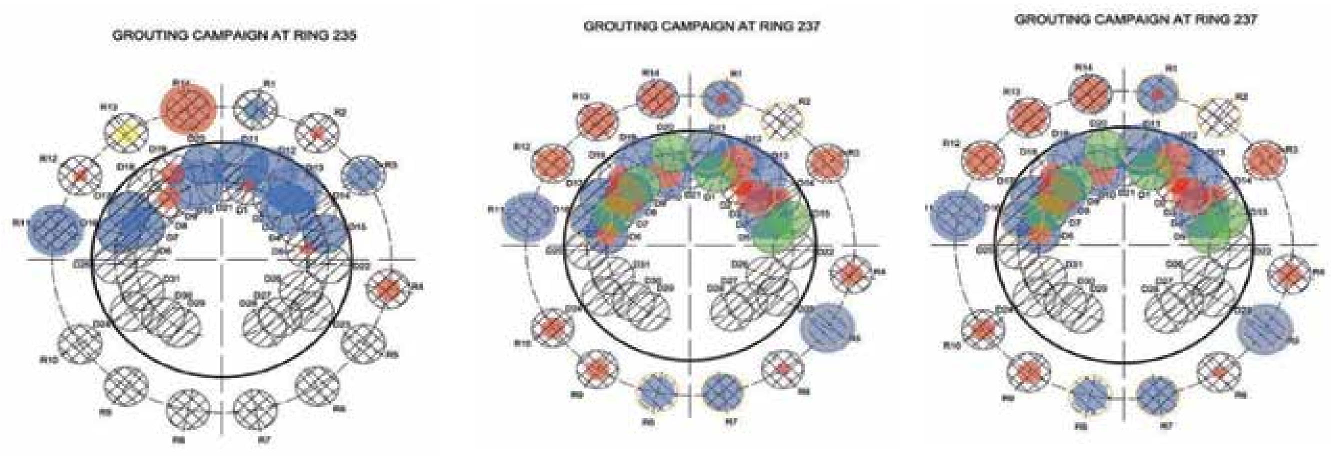


Figure 5

Water inflow 912 m³/h (4,000 gpm) and the cutterhead repair.

Lower Plate, the plan was to mine the first 200 m (600 ft) of the TBM tunnel in closed mode with face support pressure of less than 7 bar.

After 140 m (460 ft) of excavation, at push 77, the air bubble pressure was lowered and maintenance was carried out at atmospheric conditions. There, a subvertical fault entering the tunnel alignment from left to right was detected and mining resumed with pressure at the face adjusted to 12 bar to compensate for the hydraulic head. The TBM progressed very well into the detachment fault and the slurry pressure in the excavation chamber was raised to 13 bar to address the increased ground water head and the nearly cohesionless material being excavated.

On July 2, 2012, at approximately 280 m (920 ft) of excavation, the TBM penetration values became lower. The decision was made to lower the face pressure and inspect the cutterhead.

In order to assess the feasibility of men entering into the working chamber under atmospheric pressure it was important to estimate the quantity of water inflow. For this purpose, the TBM could be used to perform a large-scale piezometric test. The concept was to utilize the slurry line to measure the increase of seepage water by observing the change of water outflow in the slurry line while reducing the bubble pressure in 0.5 bar increments.

In July 2012, three piezometric tests were performed but aborted at 10 bar with more than 200 m³/h (880 gpm) of water inflow.

At this point, an inspection of the cutterhead was only possible by using a camera installed on a steel pipe pushed into the excavation chamber through a drill port equipped with a blowout preventer. The inspection showed that the cutter conditions were not bad, and on Aug. 1, 2012, the TBM resumed mining with face pressure raised to 14 bar.

Figure 6

Cascade sealing system.

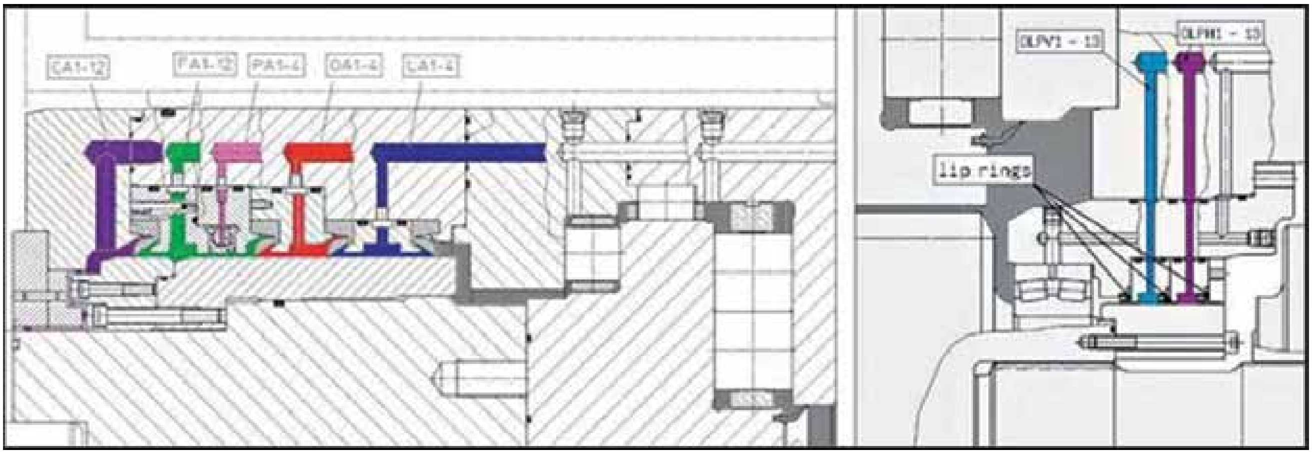


Figure 7

Chamber in front of the cutterhead.

During the next 77 pushes, 10 tests were performed and the resulting water inflows reached a maximum of 1,100 m^3/h (4,825 gpm) at 8 bar face pressure. With that inflow it was impossible to access the excavation chamber for maintenance under atmospheric pressure.

On Sept. 29, 2012, at push 235, the TBM penetration reduced. The camera inspections detected wear on the cutters. The possible scenarios were to either perform a series of pre-excavation grouting campaigns to allow for maintenance or prepare all necessary equipment for hyperbaric intervention in saturation.

Hyperbaric work at 14 bar pressure had more adherent risk, so pre-excavation grouting of the ground ahead and also around the TBM was begun. However, the hyperbaric intervention was still an option and the procurement of the gas equipment, and the logistics was planned concurrently with the grouting program (Nickerson, 2013).

Preexcavation grouting campaigns and cutterhead repair

The ground treatment ahead of the machine was planned and based on the GIN-method, refusal injection pressure and maximum injection volume values were defined in accordance with the fractured ground conditions. A significant difficulty was the fixed pattern of available drilling holes (see green and blue dots in Fig. 4).

The first grouting campaign was carried out at ring 235. The area to be grouted was planned to extend 11 m (36 ft) covering the upper part of the layout shown on Fig. 4. After some drilling and grout injection difficulties, the campaign was completed and the machine moved 4 m (13 ft) forward.

The second campaign was performed at ring 237. The umbrella was increased to 15 m (50 ft) with an overlap of 4 m (13 ft) with the first campaign. After completion of the grouting activities, the machine was moved 6 m (20 ft) forward.

The third campaign was executed at ring 240. The

Figure 8

Damaged pinion bearing and gearbox.

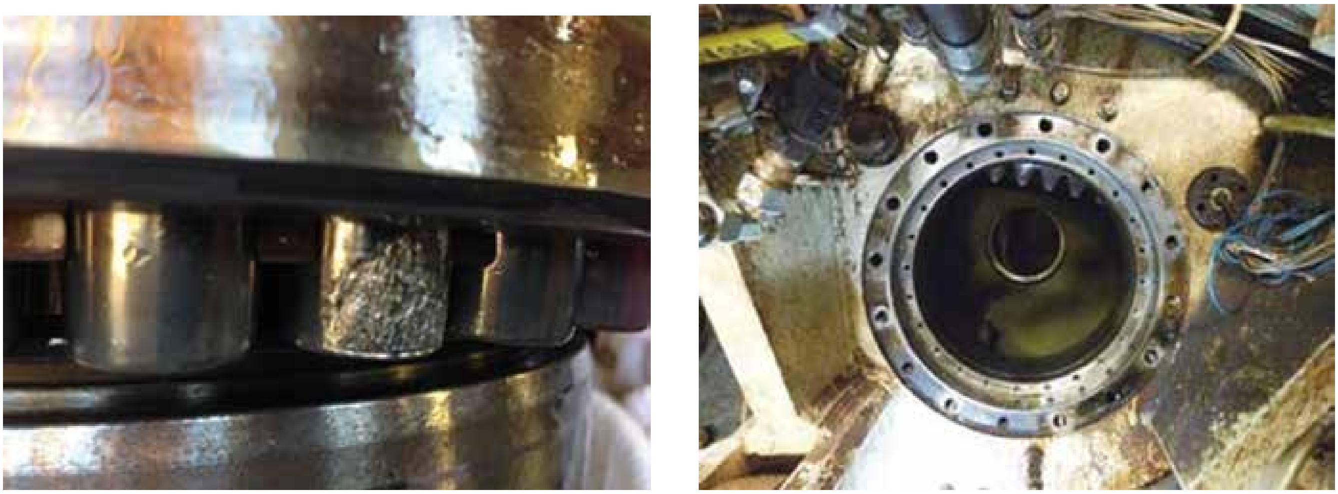
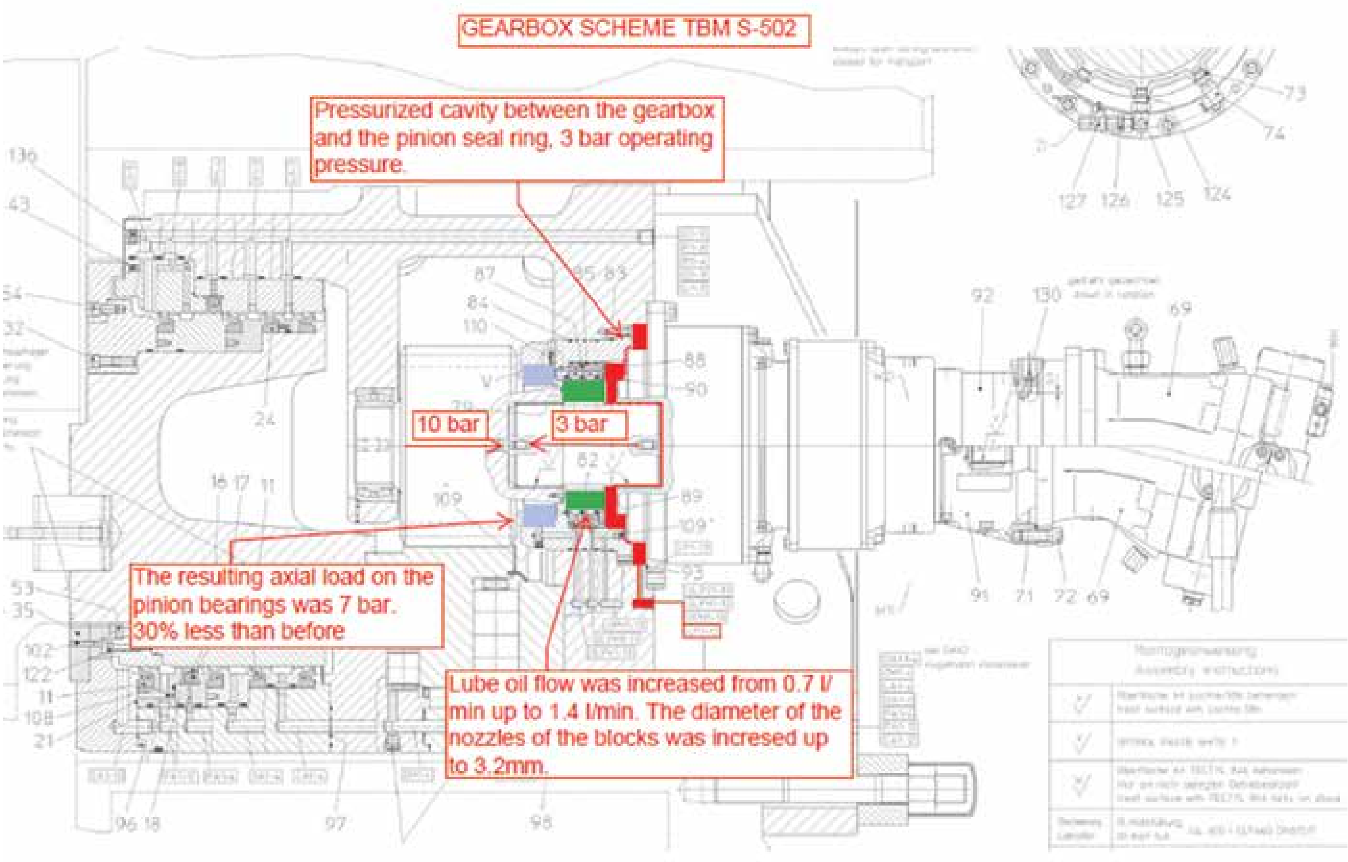


Figure 9

Damaged pinion bearing and gearbox.



umbrella was further increased to 17 m (57 ft), with 5.5 m (18 ft) overlap with the second campaign. This time, both drilling and grouting were performed in two different stages: up to 9 m (29.5 ft) for the first, and up to 17 m (56 ft) for the second.

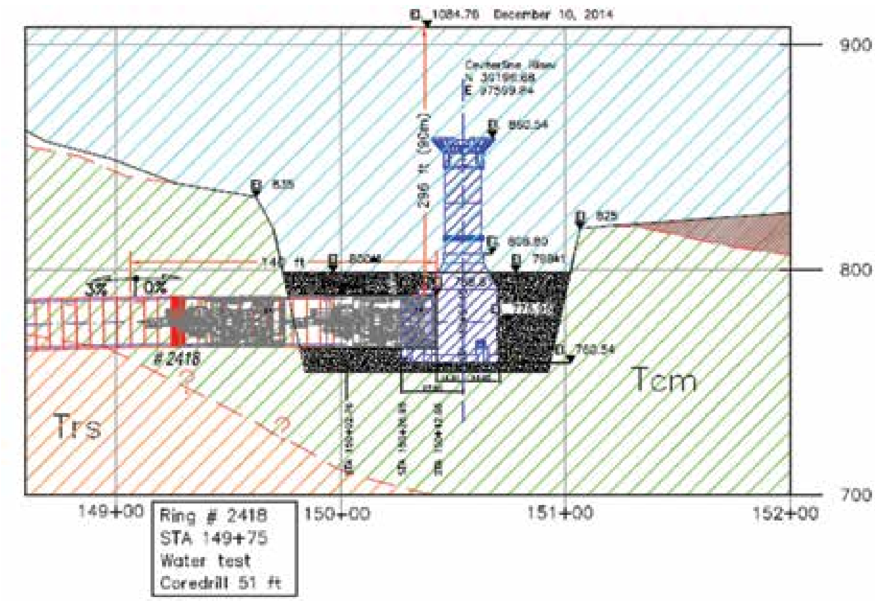
After completion of the third campaign, on Feb. 19, 2013 a large-scale piezometric test was performed. At atmospheric pressure, the water inflow was 220 m^3/h (965 gpm) and a face inspection was accomplished. Cutterhead maintenance was started, but stopped due to a local instability of the upper right part of the tunnel face. At that point, because of the low water inflow rate, maintenance of the slurry lines was performed. This included replacement of worn pipelines, valves, pumps and installation of a new hydraulic valve on the slurry return line.

When the slurry circuit maintenance was completed, the TBM advanced forward so that the unstable area was behind the TBM shield. After 9 m (29.5 ft) and then 16 m (53 ft) of advance, piezometric tests were carried out. Water inflow was 880 m^3/h (3,860 gpm) at 2.9 bar and 1,100 m^3/h (4,825 gpm) at 1.9 bar, respectively. The decision to advance forward and find a less permeable location was made, knowing that the machine was leaving the grouted area.

During advance #251 to #253 some steel fragments were found on the magnet at the slurry separation plant. It was decided to stop the TBM from advancing to investigate the problem. On March 25, 2013, a piezometric test was performed. The pressure was successfully lowered to atmospheric and the face inspection showed that the central part of the cutterhead had severe damage to the cutters and the cutter housing. The water inflow was measured to be approximately 912 m^3/h (4,000 gpm) and the rock condition was stable. With the stable conditions at the face maintenance work was started. A niche was excavated 4 m x 3 m x 1 m (13 ft x 10 ft x 3 ft) in front of the cutterhead (Fig. 5) using small hand tools. Once the excavation was completed, the structural repair was performed. The water had to be panned away from the work area and ventilation had to be established for the cutterhead repair. Technicians from the TBM manufacturer were brought to site to oversee the repair. The central section of the TBM had to be repaired completely including the disc cutter housings, structure, wear plates and the cutters (Nickerson, 2013).

Figure 10

Intake approach.



correct operation of the cutting tools (we had several cases of blocked disc cutters or disc cutters with blown gaskets). So, for the same boring force the achieved penetration was smaller. Moreover, trying to increase the penetration by increasing the boring force would squeeze the material into the gap around the shield, thus developing additional frictional forces on the shield and reducing the effective force available for boring (Anagnostou, 2013).

Cascade system replacement. On Jan. 2, 2014, after push #1309, some lubrication grease (EP2) was found in the leakage chamber P3 (Fig. 6). At that time, the TBM was mining in closed mode at approximately 12.5 bar. Production was stopped and full maintenance of the main drive lubrication system was performed.

The TBM resumed mining until ring #1337 was excavated. At STA 84+85 the machine was stopped due to low impulses of the gear box oil. The gear box and the pinion oil filter were found plugged with EP2 grease.

Herrenknecht technicians were informed and under their supervision, a series of tests were performed. It was found that it was probably one of the four cascade seals that failed allowing the lubrication grease to travel back into the main bearing and the pinions.

On Jan. 30, it was decided to replace the Cascade sealing system. In order to do that, a space between the cutterhead and the main bearing had to be excavated to allow the replacement of the seals.

Due to the length of the TBM (approximately 15 m or 45 ft) and the precast lining already in place, moving the TBM backward was not possible. So a chamber of 7.6 m x 7.6 m x 1.5 m (25 ft x 25 ft x 5 ft) was excavated in front of the machine in order to remove the cutterhead and push it forward (Fig. 7).

The chamber was completed in one week and the cutterhead was removed and pushed forward. The total seal replacement took only one month. It was discovered during this process that the second gasket between the EP2 chamber and the oil chamber P2 was broken allowing the grease to contaminate the main drive.

Production resumed on March 17 and mined through different geology without substantial problem, alternating between open and closed modes (avg. pressure 12.5 bar).

Pinion bearings repair. During push #1680 at STA 100+66, the TBM advance was stopped when metal shavings in the gearbox filters were found.

The lubrication system of the main drive were

Reach 2: Muddy Creek and Red Sandstone formation

Geology STA 31+81 to STA 149+00. The muddy creek section was characterized by different sedimentary formation. The first part was predominantly siltstone, sandstone and gypsiferous mudstone.

From STA 102+00 to STA 108+50, an intrusion of metamorphic rock, predominantly quartz-feldspar gneiss and mica schist typical of the upper plate was encountered.

However, most of reach 2 was characterized by conglomerated breccia with different levels of cohesion.

Drive. The TBM was operated in open and closed modes through this section depending on the ground conditions encountered.

The first 1,615 m (5,300 ft) of excavation were completed in six months, averaging approximately 14 m/d (45.5 ft/day).

Along this stretch teams experienced muck handling issues with the conveyor belt and clogging of the cutterhead.

In particular, it was observed that the clogging phenomena was restricted only in the areas where the clay content was higher and the TBM was advancing in closed mode applying high pressure at the face (average of 12 bar).

Due to clogging of the cutterhead, closed mode operations resulted generally in lower penetration rates. The reduction of the cutterhead openings partially obstructed the material flowing through the cutterhead.

Consequentially, the muck collected in front of the cutterhead and created a stiff layer that hindered the inspected and this time it was found that there was metal shavings in the gear box filters.

Over the next few days, further tests were conducted under the supervision of a Herrenknecht technician to isolate the problem, which potentially could have caused damage to the main bearing.

One by one all of the pinion gears were removed and inspected. Five pinion bearings were damaged and were the cause of the metal shavings in the main bearing oil. After inspection of the bull gear and the main bearing showed no signs of wear, and the the replacement of all of the 12 pinion bearings (Fig. 8) proceeded.

After approximately 100 rings from the replacement of the first set of pinion gears, there was a second failure at push #1884, STA 117+69.

A large amount of metal shavings was found in the gearbox filters. The same replacement procedure that was performed during the first pinion gears repair was started.

It was determined the failure of the pinion bearings was directly related to the high cascade pressure on the main bearing seals, which caused an unbalanced ratio axial/radial load acting on the pinion bearings. The solution was to reduce the number of drive motors from 12 to eight in order to increase the torque and to introduce a new pressurized chamber P7 (3 bar) behind the pinion bearing in order to reduce the axial load (Fig. 9).

Reach 3: Intake approach – intake connection

Geology STA 149+00 to STA 150+42. The rock formation was characterized by different flows of vesicular and non-vesicular Tertiary basalt highly fractured and predetermined to be mined in closed mode.

Drive. The intake approach was considered to be the last stretch of the drive where the alignment changed from a 3 percent grade to 0 percent grade for the final 42 m (140 ft). In the final drive, the geology changed from red sandstone to fractured vesicular basalt (Fig. 10).The TBM was operated in closed mode due to the thin cover and the large water inflow encountered.

At station 149+75 a core drill was performed to investigate the transition between the basalt and the tremie concrete including the quality of the tremie concrete and the interface of the intake "soft eye" location.

As expected, the basalt was highly fractured due to the previous blasts of the intake structure. The quality of the tremie concrete was better than expected and the result of the core drill showed a clear joint between the tremie concrete and the intake structure.

Prior to the TBM connection, AUS was mobilized to the site to set up the barges in order to perform the marine work which included:

- Removal of the lid from the intake structure.
- ROV inspection of the condition of the corbel/bulkhead and sealing flange in the interior of the intake riser.

Figure 11

Dec 10, 2014 TBM S-502 breakthrough.

- Inspection with the ROV the final position of the TBM in relationship with the intake structure.
- Setting the bulkhead once the TBM had reached its final position and dewatering the intake structure.

The TBM parameters were adjusted to reduce the rate of advance through the tremie concrete and the fiberglass reinforcement of the soft eye. This procedure reduced potential damage to the intake structure.

The excavating pressure was set at 9.3 bar during the final drive of the TBM into the intake structure, which was the theoretical lake pressure.

The material from the soft eye during the last stage of the excavation was inspected at the separation plant. The concrete previously painted on the intake structure/soft eye/intake was seen at the separation plant indicating the TBM was in the correct location. The TBM then continued to push forward until the shield stopped in line with an annulus steel ring cast in the intake structure.

After the installation of the bulkhead dewatering of the intake chamber began. Once access to the intake structure was balanced, the shunt flow around the TBM shield was measured to be 10 L/min (15 gpm) and there was no water leakage from the intake structure/bulkhead.

The Intake connection was a complete success (Fig. 11), the TBM alignment was within a tolerance of +/- 3 mm.

Conclusion and outlook

The project, for the first time worldwide, advanced a TBM at 15 bar, which required several innovations developed on site. It has been a very technically challenging and demanding project and it would not have been completed without the dedication and commitment of the Salini-Impregilo/Healy and the client Southern Nevada Water Authority working together in a true partnership. (References are available from the authors.) ■

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	2015-20	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 study
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	Bid date 4th Q 2015
Red Line Tunnel - Cooks Lane Tunnel	MD Transit Administration	Baltimore	MD	Subway	14,000	22	2016	Project delayed
Red Line Tunnel - Downtown Tunnel	MD Transit Administration	Baltimore	MD	Subway	36,000	22	2015	Project delayed
Purple Line - Plymouth Tunnel	MD Transit Administration	Baltimore	MD	Subway	1,000	30x40	2015	Bid date 4th Q 2015
Thimble Shoal Parellel Tunnel	Chesapeake Bay Bridge & Tunnel Dist.	Chesapeake	VA	Highway	5,700	45	2016	Under design
Northeast Boundary Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	17,500	23	2018	Under design
ICCS/Dekalb Tunnel	Dekalb County	Decatur	GA	CSO	26,400	25	2016	Under design
Bellwood Tunnel Phase 1 Phase 2	City of Atlanta	Atlanta	GA	Water	6,000 21,000	12 12	2016 2016	Under design Under design
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2016	Under design
Blacklick Creek San. Interceptor Tunnel	City of Columbus	Columbus	OH	Sewer	24,000	10	2015	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2016 2017	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 8/13/2015
Continental Rail Gateway	CRG Consortium	Detroit	MI	Rail	10,000	28	2015	Under design
ALCOSAN CSO Program	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	35,000	20	2016	Under design
Lower Pogues Run	Indianapolis DPW	Indianapolis	IN	CSO	9,000	18	2016	Under design
White River Tunnel	Indianapolis DPW	Indianapolis	IN	CSO	28,000	18	2016	Under design

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Three Rivers Protection/Overflow	City of Fort Wayne	Fort Wayne	IN	CSO	26,400	12	2017	Under design
Albany Park Stormwater Diversion	Metro.Water Reclamation Dist.	Chicago	IL	CSO	5,700	18	2015	Bid date 8/27/2015
St. Louis CSO Expansion	St. Louis MSD	St. Louis	MO	CSO	47,500	30	2014	Under design
KCMO Overflow Control Program	City of Kansas City, MO	Kansas City	MO	CSO	62,000	14	2014	Under design
Mill Creek Peaks Branch Tunnel	City of Dallas	Dallas	TX	CSO	5,500	26	2014	Advertise 4th Q 2015
Downtown Bellevue Tunnel - E330	Sound Transit	Seattle	WA	Transit	2,000	40x30	2015	Bid date 9/23/2015
L.A. Metro Regional Connector	Los Angeles MTA	Los Angeles	CA	Subway	20,000	20	2014	Skanska-Traylor JV Awarded
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 Under design 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	2015	RFQ under way
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	Under design
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
Iowa Hill Pumped Storage Project	Sacramento Muni. Utilities District	Sacramento	CA	Water	3,500	20	2018	Under design
SVRT BART	Santa Clara Valley Trans Authority	San Jose	CA	Subway	22,700	20	2016	Under design/ Delayed
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2015	Under design
Yonge St. Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2016	Under study
Scarborough Rapid Transit Extension	Toronto Transit Commission	Toronto	ON	Subway	25,000	18	2017	Under design
CSS - East-West	City of Ottawa	Ottawa	ON	CSO	14,400	10	2015	Under design
CSS - North-South	City of Ottawa	Ottawa	ON	CSO	5,300	10	2015	Under design
Energy East Pipeline	TransCanada	Quebec City	QC	Oil	13,780	16	2015	Under design
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	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

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UCA of SME

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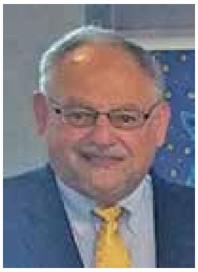
EXECUTIVE COMMITTEE

Highlights of the UCA Executive Committee meeting

The Executive Committee of the UCA of SME met during the Rapid Excavation and Tunnelling Conference in New Orleans, LA on June 10, 2015. The board confirmed the new slate of officers for the coming year — **WILLIAM EDGERTON** as past chair, **ARTHUR SILBER** as chair and **MIKE ROACH** as vice chair. Two new members joined the executive committee with terms starting immediately. Red Robinson joined the board as a representative in the engineering category and Tony O'Donnell joined in the contractors category.


EDGERTON


SILBER


ROACH

The committee reviewed the current state of business affairs for the UCA. Among the topics discussed included keeping the current corporate and sustaining membership structures as they are. The group also discussed the George A. Fox Conference, which underperformed slightly because of the snow storm that shut down New York City in January, and the Cutting Edge Conference, being held in Denver, CO this year.

Strategic goals for the division were presented to the executive committee. Those goals are:

- Become the primary resource for underground construction issues and information requests.
- Improve the image of underground construction in the minds of the public, government, owners and key constituencies.
- Improve the effectiveness and efficiency of the underground construction industry.

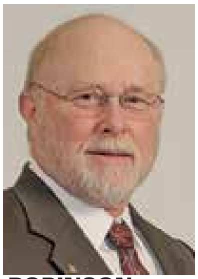
The committee approved the creation of a new UCA of SME Scholarship Committee chaired by Mike Roach. It includes Erin Clarke, Pam Moran and Greg Hauser. More volunteers will be contacted about joining. The committee's first task is to develop a new application path for tunneling/civil engineering students.

In 2016, students will not have to be UCA of SME members to apply. The executive committee will meet next in conjunction with the George A. Fox Conference in January 2016. ■

Robinson and O'Donnell join UCA Executive Committee

Red Robinson and Tony O'Donnell, members of the UCA Division of SME, joined the UCA Executive Committee at the Rapid Excavation and Tunnelling Conference (RETC) in New Orleans, LA.

ROBERT "RED" ROBINSON, CEG, is director of underground services and senior vice president at Shannon & Wilson Inc. He has more than 40 years of experience on geotechnical assessments and has participated in the design and construction of more than 70 tunnels in the Puget Sound area. These ranged in size from 0.9 m (3 ft) in diameter by 914 m (3,000 ft) long directionally drilled utility lines to the world's largest diameter softground tunnel at 19.5 m (64 ft) ID. for Interstate 90.


ROBINSON

Currently, Robinson is involved with tunnels in California, Oregon, Missouri and Washington. He has published more than 60 technical papers on various aspects of geotechnical exploration, design, construction and construction monitoring for tunneling in soil and rock. He has been on a variety of tunneling industry committees including the Underground Technology Research Committee, the AEG Tunneling Committee and the Rapid Excavation and Tunneling Conference Committee. He has also assisted with a variety of short courses on ground improvement, rehabilitation and instrumentation for trenchless and large diameter tunnels.


O'DONNELL

TONY O'DONNELL is the engineering director with Kiewit's Underground District. He is currently on the startup team for the $707 million Rondout-West Branch bypass tunnel. He received his B.E. in civil

EXECUTIVE COMMITTEE

engineering from University College, Cork, Ireland in 1986 and an M.Eng. in sanitary engineering in 1988. He is a professional engineer registered in Washington, D.C.

O'Donnell began his career in 1988 with Mergentime/Morrison Knudsen on the $60 million Washington Metropolitan Area Transit Authority (WMATA) Navy Yard station and the East Tunnels project. In 1995, he joined Kiewit on the WMATA New Hampshire Ave. tunnels. During the next 10 years, he worked in various roles on a variety of Kiewit underground projects along the Eastern seaboard. From 2005 to 2009, he was part of the successful $425 million Portland East Side Combined Sewer Overflow tunnel project in Portland, OR, working as the engineering manager.

Between project assignments, O'Donnell has overseen the Kiewit Underground District's business development, estimating and engineering efforts for all of its underground and tunnel projects in North America. ■

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 2016 to 2020. 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. 27, 2015. Please remember that the individual 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.

- Please 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

HENN

RAY HENN (SME), with 40 years of experience in the tunneling and underground construction industry, has formed his own consulting company, RW Henn LLC, Heavy and Underground Construction Consulting. He plans to focus his service offerings on serving on dispute resolution boards, bid support to contractors, underground grouting, claims evaluation, negotiations and arbitration/litigation support, serving as an expert witness, conducting tunnel inspections and condition surveys, and serving on value engineering teams. He is an adjunct professor in underground construction and tunneling at the Colorado School of Mines.

MATTHEW TIBBUTT is the new senior project manager with Geocomp's consulting division in Massachusetts and will lead the instrumentation and monitoring department at the Boston, MA office. Tibbutt will support the company's key projects, such as the Los Angeles Metro Crenshaw/LAX Corridor as well as local projects for MassDOT and MBTA. He has worked on London's Crossrail Project and the Burj Khalifa in Dubai.

TIBBUTT

Brierley Associates has opened an office in Houston, TX to complement its Austin-based operations. The Houston office is headed by Brierley's newest associate, **NANCY NUTTBROCK**, PE. She has 20 years of experience in tunneling and underground construction, engineering and regulatory knowledge of mining and project management. She has recently served with the state government of Wyoming. ■

UCA SCHOLARSHIPS

UCA scholarships are presented at 2015 RETC

Every year, the Executive Committee of the UCA of SME awards several scholarships to the most qualified candidates who apply for the stipends. In 2015, five awards were made. In addition to the cash awards, travel expenses and free registration to the annual conference are given to the recipients.

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

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

Any prior experience, such as internships or summer jobs in the tunneling or underground industry in the planning, design, construction or operation of tunnels and shafts, is a benefit to the applicant being considered. The applications are available at www.smenet.org/students/grants-scholarships.

UCA Division scholarship winners

The Executive Committee of the UCA of SME presented five scholarships at the UCA luncheon during the Rapid Excavation and Tunneling Conference (RETC) in New Orleans, LA this June. Each scholarship recipient also received full conference registration, airfare, hotel accommodations, the proceedings volume, tickets to conference events and a stipend for other expenses.

LISA MORI is pursuing a Ph.D. in the Department of Mining and Earth Systems Engineering at the Colorado School of Mines. She is the vice president of the UCA Student Chapter at CSM. Mori has worked as a research intern or engineering intern for JCM N125 tunnels in Seattle, WA, Brierley Associates, Denver, CO and IGT Salzburg, Austria. She has an undergraduate degree from the University of Leoben, Austria.

SIMON PRASSETYO is a graduate student pursuing a Ph.D. at the Colorado School of Mines in the Department of Civil and Environmental Engineering. He plans a case study in modeling ground response of the Caldecott Fourth Bore Tunnel in Oakland, CA. He was a summer intern with Freeport-McMoRan at the Henderson Mine in Colorado and with Golder Associates at the Bingham Canyon Mine. He has been active in the UCA student chapter, as a volunteer for the Salvation Army and in his local church. He has an undergraduate degree from the Institut Teknologi Bandung, Indonesia and a master's degree from West Virginia

Art Silber (far left) and William Edgerton (far right) presented UCA Division scholarships to (l-r) Kevin Schaeffer, Yulani Wu, Simon Prassetyo, Lisa Mori and Hamed Zamenian at the 2015 RETC.

UCA SCHOLARSHIPS

University on a Fulbright Scholarship.

KEVIN SCHAEFFER is a graduate student pursing a Ph.D. in the Civil and Environmental Engineering Department at the Colorado School of Mines, where he is also the outreach officer for the UCA of SME Student Chapter. He is a member of the Colorado Association of Geotechnical Engineers and was selected to lead a Young Professionals program for the group. He has interned for Peter Kiewit and Sons at the Black Butte surface coal mine and with Kiewit's underground group at the Devil's Slide Tunnel in California. He received his bachelor's and master's degrees from CSM and was a member of the Civil Engineering Honor Society.

YULANI WU is pursuing a Ph.D. at the Colorado School of Mines in the Department of Civil and Environmental Engineering. She is a member of the UCA of SME Student Chapter. She received an Edna Bailey Sussman internship where she worked on a collaborative project in the Appalachian Mountains involving the U.S. Geological Survey Landslide Hazards Program, CSM and the North Carolina Geological Survey. Wu received her bachelor's and master's degrees from the China University of Geosciences.

HAMED ZAMENIAN is a Ph.D. student in the School of Civil Engineering at Purdue University. He is a graduate teaching assistant in the Environmental Improvement Initiative, Engineering Projects in Community Service program and a graduate research assistant in the Center for Underground Tunneling Education and Research. He has worked in the Waste-to-Energy program at the Lugar Center for Renewable Energy, on the Indy Deep Rock Tunnel project in Indianapolis, IN and in several underground pipeline rehabilitation projects. He holds a bachelor's degree in civil engineering from Shomal University in Iran and a master's degree in construction engineering management technology from Purdue. He has authored or coauthored more than 18 papers and poster presentations and is a lead member of Tau Beta Phi, national engineering honor society. ■

RETC SCHOLARSHIPS AND AWARDS

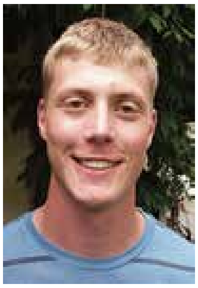
The Rapid Excavation and Tunneling Conference (RETC) Executive Committee annually awards one or more scholarships to students who wish to develop their skills in the rapid excavation and tunneling field. The committee awarded four scholarships at the June 2015 RETC in New Orleans, LA. Each scholar also received a stipend for expenses to attend the conference.

RETC scholarship winners

ROBERT A. GODINEZ is pursuing a master's degree in civil-geotechnical engineering at the Colorado School of Mines. As an undergraduate at Lamar University, he was project manager for two concrete canoe competitions and president of Chi Epsilon civil engineering honor society. He has worked as an intern for Parsons Brinckerhoff in Los Angeles, CA on the Westside Subway Expansion project, plus six additional geotechnical internships. He is a member of the UCA Student Chapter at CSM and presented a paper at the 2015 RETC.

GODINEZ

KOEN DUINEVELD is an undergraduate student at the University of British Columbia majoring in mining and mineral processing engineering. He is active in intramural sports and is the sports representative from the UBC mining department to the university. He has worked in landscaping and construction and as a math tutor.

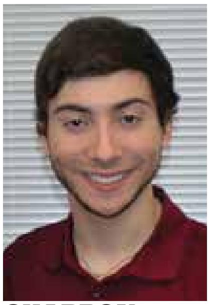


DUINEVELD

JOHN M. MEYER is a student and research assistant pursuing a Ph.D. in mining engineering at the Colorado School of Mines. Since 2008, he has worked in his own consulting business mapping geological hazards, landslides and rock falls, analyzing surface water hydrology, trenching studies and soil analysis, generating maps and preparing client reports. Previously, he worked for Quantum Technology Sciences as a geophysicist investigating seismic waves and seismic signal detection to locate miners trapped underground.

MEYER

CHASE CHARRON is a junior studying mining engineering and green engineering at the Virginia Polytechnic Institute and State University. As a member of the Burkhart Mining Society, the SME Student Chapter, he participates in intramural sports, and is also a member of ISEE. Charron was a summer intern at Unimin Corp. in Spruce Pine, NC working with mine waste water problems, blasting layout and processing.



CHARRON

RETC SCHOLARSHIPS AND AWARDS

RETC Attendance Awards

The goals of the RETC student conference scholarship program are to provide students with skills and information for a career in the underground industry and to provide 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 management.

The 2015 awards paid the travel expenses for seven students who wished to attend the 2015 RETC in New Orleans, LA.

Application forms for RETC scholarships and Attendance Awards can be found on the SME website at www.smenet.org/scholarships.

The 2015 award recipients were:

- Jessica Buckley, Colorado School of Mines.
- Gopi Bylapudi, Southern Illinois University-Carbondale.
- Jacob Grasmick, Colorado School of Mines.
- Caitlyn McKinley, Queens University, Kingston, ON, Canada.
- Dallas Rolnick, University of New Orleans.
- Daniel Rowles, Virginia Tech.
- Rahul Thareja, University of Nevada, Reno. ■

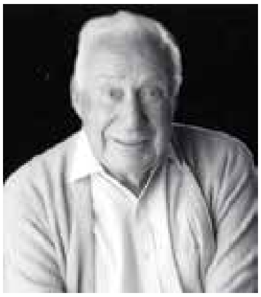
OBITUARIES

JACK J. BURKE

An appreciation by George Yoggy

As common as rock and drilling are to tunnel construction so, for the past 65 years, has Jack Burke been to those in and around the underground industry. From his early days as a young engineer, designing and building equipment to break and move rock, to his later years guiding and supporting engineers and contractors challenged by underground projects, Burke was known to nearly everyone involved in the tunneling business, at home and around the world. His friends are many, and long is the list of those with memories and gratitude for his wisdom, experience, guidance and support.

Mr. Burke, as many refer to him, began learning his craft the old fashioned way. In 1946, following four years of service in the U.S. Navy, he returned to Brooklyn, worked on the New York aqueduct and other projects and completed his engineering degree. He then joined Gardner Denver to learn what tunnel equipment and tunneling was all about. As a field engineer, he quickly became involved with the design and engineering of drilling equipment and how it was used at various projects around New York and New England. His passion for making things work and learning from others, as well as sharing his skills, quickly endeared him to tunnel stiffs and contractors alike.



BURKE

Burke's love for the work and the trust of the men made him a messenger in the realm. To further communicate the progress of projects and the men involved, he began writing the *Hard Rock News* as a means to let people know what was going on. Networking is a modern term for business and industry, but the early tunnel builders relied on the word passed from one tunnel hand to another and for many years *Hard Rock News* was the way to keep in touch. And, of course, his talent for writing and penchant for sharing fostered the infamous "Tunnel Stiffs Tales." He was also a contributing editor to many tunnel industry publications.

Burke continued developing means and methods for improving drilling and benefitting the underground industry throughout his career with Gardner Denver and following with the Sullair Mining Equipment Division. He retired from Gardner Denver in 1988 and continued to consult to the industry for many more years. His support of Jack Lemley and the Channel Tunnel project provided an opportunity to be present at the "holing through" and he became one of the first to walk from England to France on Dec. 1, 1990.

Honors and recognition have been rightly abundant for a man who has given so much to the tunnel industry. Burke has been a member of The Moles since 1962 and was honored as a Life Member in 2012. "For his tireless efforts to improve industry standards and for his generosity in sharing his findings," he was presented with the Golden Beaver Award for Service and Supply in 1992. The American Underground Construction Association, now UCA of SME, presented Burke with the Lifetime Achievement Award in 2005.

Burke was a man born in the 20s, raised in the 30s, served in the 40s, worked, learned and trained in the 50s, shared, grew, mentored and led from the 60s into the 21st century.

On Jan. 14, 2015, industry personnel held a very special celebration dinner in Los Angeles, CA to honor Burke for a lifetime of contributions to the tunnel industry. The attendees were longtime industry colleagues and family members. A special booklet was prepared and presented to him and the guests that highlighted the various lifetime contributions and achievements he made during

OBITUARIES

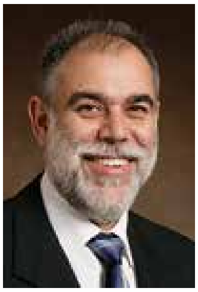
his career. He was very moved that the industry he so loved would hold such a special dinner to honor him, and he was humbled by the experience. This was an indication of his character. He died July 5, 2015.

Jack, rest in peace knowing that most of what you left behind is still working. Many thanks. ■

In memoriam

JAMES McKELVEY

James McKelvey, a respected and internationally recognized tunnel design, construction and risk management expert, died suddenly on July 20, 2015, at the age of 60.



McKELVEY

McKelvey was born in South Africa on Sept. 15, 1954 and earned his bachelor's degree in civil engineering from the University of Natal in 1976. That same year, he joined Murray & Roberts Roads and Earthworks and began work on numerous South African tunneling projects.

He joined Keeve Steyn Inc. in 1980 and, during his more than 20-year career with the company, became recognized as one of the foremost tunneling engineers in South Africa. He led the company's tunneling team and many major projects, such as the Inanda-Wiggins Tunnels and the Midmar Potable Water Tunnel. In 1998, he accepted the position of chief resident engineer on the Matsoku Weir and Diversion Tunnel, followed by the same role on the 32-km (20-mile) long Mohale Tunnel. Both projects were parts of the Lesotho Highlands Water Project, one of the largest water transfer programs ever developed in Africa and recognized as the Project of the Century by the South African Institution of Civil Engineering.

McKelvey joined Black & Veatch in 2002 as a senior member of the company's geo-engineering group. In 2003, he moved to Charleston, SC to lend his talents to a multiphase wastewater tunnel replacement program. As an associate vice president at Black & Veatch, he began the company's Tunneling Center of Excellence in Indianapolis, IN before becoming the tunnel chief engineer in 2013. During his 13-year career at Black & Veatch, he worked on many of the company's large-diameter tunnel and pipeline projects throughout North America. He played key roles on tunneling projects and programs in Indianapolis, IN, Fort Wayne, IN, Louisville, KY, Columbus, OH, Omaha, NE, Las Vegas, NV, Washington, D.C. and Toronto, ON, Canada, in addition to his work in Charleston and many other locations.

McKelvey left a lasting legacy by mentoring many professionals along the way, and he has also left an indelible mark on the industry as a tunneling authority known for practical, insightful solutions to complex design and construction challenges. He served on the Executive Council and the Organizing Committee of the International Tunneling Association, and he represented Black & Veatch as a sustaining member of the Underground Construction Association of SME.

Within the UCA, McKelvey served as a member of the George A. Fox organizing committee. He was a member of the organizing committee for the ITA-AITES World Tunnel Congress 2016 to be held in San Francisco, CA. He also served as a member of the ITA working group on shotcrete, a tutor of the ITA working group on contractual practice, chair of the South African National Council on Tunneling and of the council's working group on shotcrete. He authored numerous papers and chapters of books, including a logistics chapter in *Megaprojects: Challenges and Recommended Practices*.

McKelvey is survived by Jacqui, his wife of 12 years, five children, two grandchildren and a sister. ■

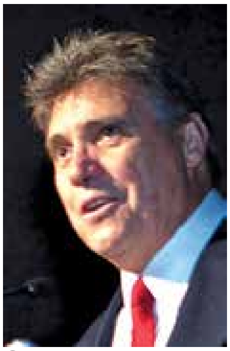
In memoriam

EDWARD CRUZ

Edward Cruz, husband, father, grandfather, entrepreneur, humanitarian and author, died July 14, 2015.

Born in Camarneira, Portugal on March 22, 1941, he emigrated to the United States at age nine, settling in the Ironbound section of Newark, NJ. Cruz later graduated from the Newark College of Engineering and became a professional engineer in 1968. After working alongside his father and brothers for 20 years, Cruz partnered with his best friend and cousin, Evaristo G. Cruz, to found E.E. Cruz and Co. in 1984. During the next quarter century, E.E. Cruz became one of the most respected construction firms in the country, specializing in tunnels, bridges, deep foundations and infrastructure work.

Cruz's accomplishments and contributions to his community and the construction industry are legendary. He was a former president of the National Utility Contractors Association, the General Contractors As-



CRUZ

OBITUARIES

sociation of New York, the Utility and Transportation Contractors Association of New Jersey and The Moles. He was a trustee of the Associated General Contractors of New Jersey and a member of the New Jersey Construction Hall of Fame.

Cruz served as mayor of Holmdel, NJ, helped create the Ironbound Bank and served on the boards of the Richmond County Savings Bank Foundation and Monmouth University. In 2013, he received a Doctor of Science, honoris causa, from New Jersey Institute of Technology.

A few of Cruz's favorite causes included St. John's Church, the Portuguese Heritage Scholarship Foundation, the Lafayette Street School, the Trust For Public Land, and the New Jersey Performing Arts Center in Newark. He was an antique automobile collector and major force behind the Monmouth County Concours d'Elegance, New Jersey's classic motorcar festival benefitting local worthwhile charities.

Cruz is survived by Sharon, his wife of 51 years, four children and 10 grandchildren. ■

NEW MEDIA

Jet Grouting: Technology, Design and Control

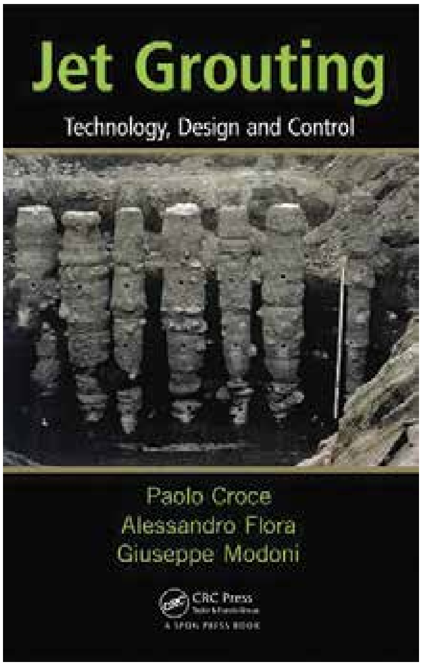
2014 by Paolo Croce, Alessandro Flora, Giuseppe Modoni, published by CRC Press, an imprint of Taylor & Francis, email orders@crcpress.com, www.crcpress.com, hardcover, 302 pp, ISBN 9780415526401, $103.96.

Jet Grouting: Technology, Design and Control analyzes typical jet-grouted structures, such as foundations, earth-retaining walls, water cutoffs, bottom plugs and tunnel supports, and it serves as a practical manual for the correct use of jet grouting technology.

Unlike similar titles providing general information on ground improvement, this book is entirely devoted to the role of jet grouting — its methods and equipment, as well as its applications. It discusses the possible effects of jet grouting on different soils and examines common drawbacks, failures and disadvantages, recent advances, critical reviews and the range of applications, illustrated with relevant case studies.

Jet Grouting addresses technology issues, the interpretation of the mechanisms taking place during the grouting, the quantitative prediction of their effects, the design of jet-grouted structures and the procedures for controlling jet grouting results. It also discusses the design criteria for jet grouting projects and reviews existing design rules and codes of practice of different countries

The book provides practical methods for design calculations of the most important jet-grouted structures, such as provisional tunnel supports, and includes the current standard control methods and most innovative techniques reported for the implementation of quality control and quality assurance procedures. ■



2016 WORLD TUNNEL CONGRESS

San Francisco is host to 2016 WTC

The World Tunnel Congress (WTC) 2016 will be held in San Francisco, CA at the Moscone Center on April 22-28, 2016. Housing and event registration opened in June at www.WTC2016.us.

UCA member companies will be asked to help with the promotion of the conference, which attracts as many as 2,500 attendees from around the world. The conference also offers as much as 3,252 m^2 (35,000 sq ft) of exhibit space.

WTC 2016 is unique in that it will be held in lieu of the UCA's biennial North American Tunneling (NAT) Conference, so the resources, talents and participants of the NAT will now be found at the WTC in San Francisco. Watch for more information at www.wtc2016.us. ■

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