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TUNNELING & UNDERGROUND CONSTRUCTION

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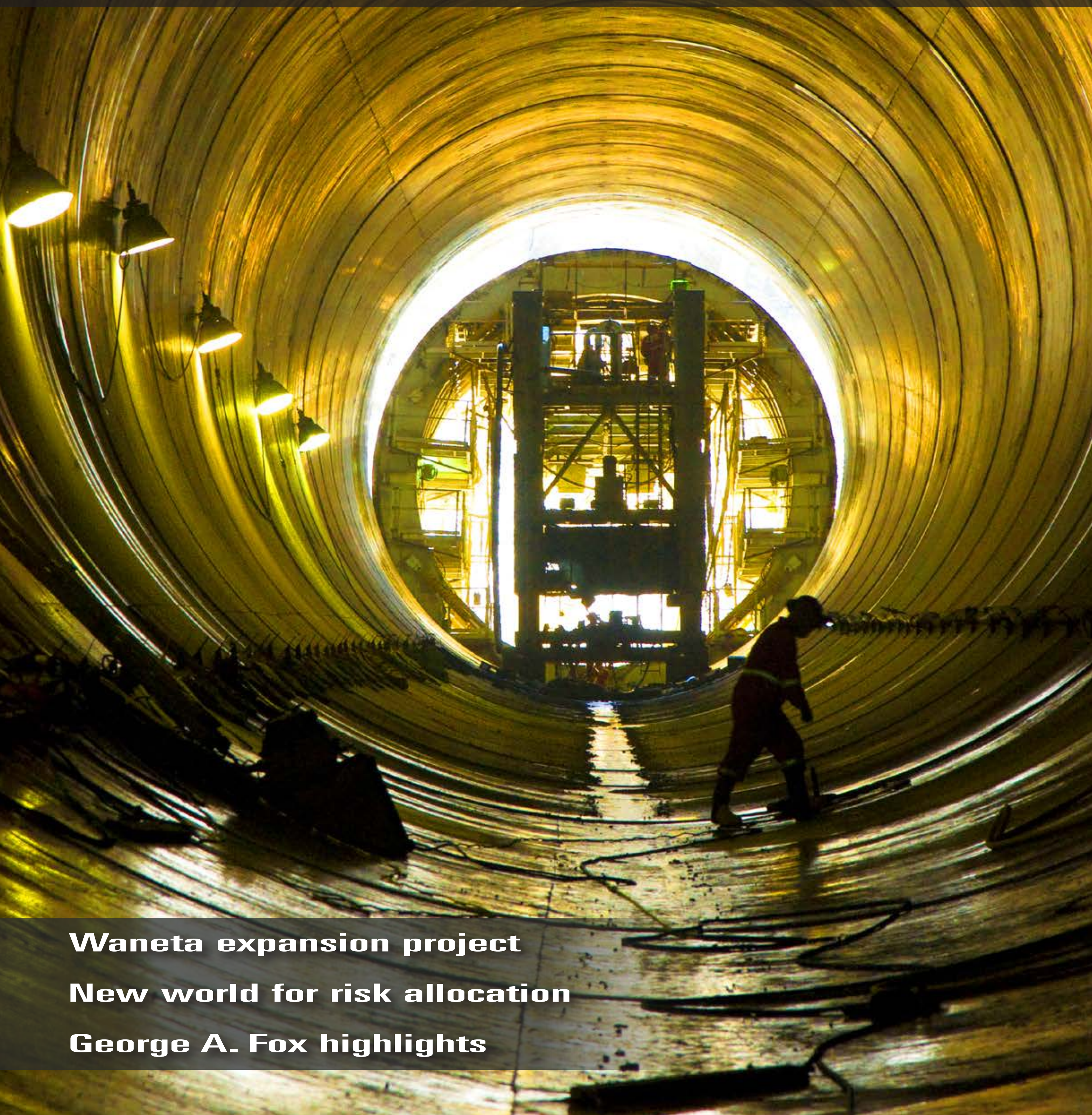

Waneta expansion project

New world for risk allocation

George A. Fox highlights

Special Editorial Section from the publisher of *Mining Engineering*

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TUNNELING & UNDERGROUND CONSTRUCTION

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COVER STORY

In this issue — The Waneta Expansion Project, located at the confluence of the Pend d'Orelle and Columbia rivers near Trail, BC, will consist of a new 335-kW powerhouse including two turbine units. Water will be funneled through an intake structure and two concrete-lined penstock tunnels, page 59. Photo courtesy of the Waneta Expansion Project.

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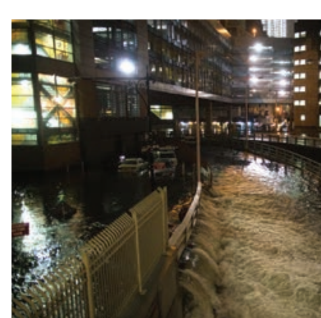

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CHAIRMAN'S COLUMN

Where will we find the people?

At the recent George A. Fox Conference in New York City, attendees got an update on the status of future projects. The general consensus is that the state of the industry is excellent, and improving economic conditions bode well for future underground work in the United States. One recurring concern, however, is that there are not enough people entering the workforce to replace those who are exiting (through retirement or other means), to say nothing about handling any sort of increased workload.

Where will we find the necessary staff to do this work? It is not likely to come from the colleges and universities that turn out tunneling engineers. By my reckoning, you can count on one hand (without using all your fingers) the number of institutions in the United States that have a tunneling engineering curriculum. Add a few more, if you count those offering individual courses. And, as owners, engineers, suppliers and contractors, we won't be able to staff our projects by stealing employees from our competitors in this industry or from our counterparts in other industries. Instead, we have to grow the underground industry ourselves to get to where we want to be.

To do that, we must be involved in underground engineering education at three levels. First, we have to increase the interest in underground engineering — some would say all kinds of engineering — in our secondary schools. Improving STEM (science, technology, engineering and mathematics) education is the focus of many U.S. organizations, from the NSF to NASA. Representatives of the underground industry can help, and it's easy and fun to do. Arrange to go to a high school assembly or science class and give a short PowerPoint presentation on what you do every day. Schools are glad to have people from the real world come and talk to the kids. Show lots of pictures. You would be surprised at the questions you get from the students, and it might even kindle an interest.

Second, we have to provide input to college and university curricula. I have spent the last 12 years visiting civil and construction engineering programs throughout the country, and I am amazed at how feedback from those of us in the industry is welcomed by faculty and administrators. These programs, from which we get entry-level engineers, need to know what sorts of training and education we require. We have an obligation to give this information to them to enable them to tailor their programs so that graduates have the skills that we need.

Last, we need to recognize that, as employers, we have a role in developing our staff. We expect them to come to us with a certain level of training (knowledge and skills) and education (which includes knowing how to learn). The training enables them to contribute immediately to our organization, while the education enables them to identify changes (both in the industry and the job) and adapt their skill set to meet those changing needs. We must also recognize the types of training that we, as employers, have to provide to ensure that we can successfully complete the projects that we undertake.

So I encourage all of you to consider what you can do to improve the quality of people in this industry. You can awaken interest and increase the number of entrants, provide opportunities for learning by contributing to the college curricula, and/or mentor existing employees to increase their value. ■

William W. Edgerton,
UCA of SME Chairman

California drought puts renewed focus on Bay Delta Conservation Plan

The Bay Delta Conservation Plan (BDCP) is a 50-year plan with the goal of securing California's water supply with the construction twin 48-km (30-mile) tunnels that would carry water from the northern part of the state to the farms and cities to the south.

California Gov. Jerry Brown has already endorsed the project and now, in light of the worst drought the state has seen in decades, there is a renewed push for the $15 billion project from the governor's office.

Bloomberg reported that, in his State of the State speech in January, Brown urged support for the Bay Delta Conservation Plan, which includes the tunnels, saying it should be part of a broader effort to protect the state from droughts in the future.

"Among all our uncertainties, weather is one of the most basic," he said. "We can't control it. We can only live with it, and now we have to live with a very serious drought of uncertain duration."

The tunnels would help bolster the ecosystem of the Sacramento-San Joaquin River Delta, which is on the verge of collapse from feeding water to 25 million people and 304,000 ha (750,000 acres) of farmland.

The drought, which officials say could be one of the worst in California's history, is forcing farmers in the fertile central valley region to fallow thousands of acres of fields and has left 17 rural towns so low on drinking water that the state may need to start trucking in supplies. The tunnels are the biggest part of a $25-billion Bay Delta Conservation Plan.

According to state data, reservoirs are at about 60 percent of average and falling as rainfall remains at record low levels. Mountain snowpack is about 12 percent of normal for this time of year. Brown is urging the state's 38 million residents to conserve and warning that mandatory restrictions are possible.

California, the top U.S. agricultural producer at $44.7 billion, needs water to produce everything from milk, beef and wine to some of the nation's largest fruit and vegetable crops. Lost revenue this year from farming and related businesses such as trucking and processing could reach $5 billion, according to estimates by the California Farm Water Coalition, *Bloomberg* reported.

The tunnels would permit the state to begin pumping water directly from the Sacramento River at the northern end of the Sacramento-San Joaquin Delta to protect endangered smelt, salmon and other fish being killed by the existing water pumping system in the southern delta.

The tunnels would move as much as 255 m^3 (9,000 cu ft) of water per second. The state now is forced to curtail flows to a fraction of that because of the fish kills.

Proponents say the tunnels would also better protect the state's water supply from earthquakes, which could collapse levees along the delta and flood the area with saltwater.

The plan would spend an additional $10 billion over 50 years to restore almost 61,000 ha (150,000 acres) of wetlands and other wildlife habitat and to shore up hundreds of miles of levees. Water customers would pay for the tunnels through higher monthly bills. Taxpayers would have to cover some of the cost of the restoration.

About two-thirds of Californians get at least part of their water through the State Water Project. Besides serving households and businesses, the system irrigates crops in the San Joaquin Valley near the center of the state — the world's most productive agricultural region.

It was Brown's father, the late former governor Edmund G. "Pat" Brown, who championed the State Water Project, asking voters in 1960 to approve $1.75 billion of bonds to begin construction. Today, the system includes 34 reservoirs, lakes and storage facilities, 20 pumping stations, five hydroelectric power plants and more than 1,126 km (700 miles) of aqueducts and pipes, making it one of the largest public-owned and operated water systems in the nation.

State water department officials said on Jan. 31 the deepening drought means they won't be able to deliver any of the 4 million acre-feet of water sought by local agencies from the State Water Project. An acre-foot is the volume needed to cover an acre of land one foot deep with water.

Enough water will continue to flow to maintain public health and safety, the department said. The state is curbing delivery so that a small amount can be held in shrinking reservoirs to keep salt water from seeping into the delta and damaging the water supply.

California gets most of its rain in December, January and February. Los Angeles, which normally gets almost 38 cm (15 in.) of rain a year, got less than 10 cm (4 in.) in 2013, according to the National Weather Service. San Francisco, where 55 cm (22 in.) is typical, got 15 cm (6 in.).

"We are in an unprecedented and very serious situation," Brown said Jan. 17, when he declared a statewide drought emergency. ■

TBM progressing well at Municipal Railway project in San Francisco

The San Francisco Municipal Transportation Agency (SFMTA), which manages transportation in the city, including the Municipal Railway (Muni), announced on Jan. 28 that the Central Subway's second tunnel boring machine (TBM) would soon pass beneath Powell Street Station and the existing Bay Area Rapid Transit (BART) and Muni Metro tunnels, passing under Market Street from SoMa into Union Square.

When the Central Subway opens, the new tunnels will allow T Third Line trains to travel quickly beneath 4th Street and Stockton Street, cutting transit travel times by more than half along this busy corridor, SMFTA said in a release.

The SFMTA has worked in close coordination with BART and an independent panel of top tunneling experts to plan and carry out this key phase of tunnel construction. The new T Third Line tunnels will be about 3 m (10 ft) below the existing BART tunnels.

The TBM, Big Alma, will be in operation 24 hours a day to build the approximately 130 m (425 ft) of new tunnel beneath the Market Street tunnels.

In late 2013, the first TBM, Mom Chung, safely and successfully completed the same undercrossing, using the same techniques and interagency coordination. Mom Chung is now beginning to tunnel under Nob Hill, heading toward Chinatown. Including both tunnels, tunneling contractor Barnard Impregilo Healy (BIH) has constructed more than 2,100 m (6,900 ft) of tunnel under 4th Street and Stockton Street so far.

In preparation for the crossing, the contractor has injected a ground-stabilizing grout underground near the BART tunnels, accessing this subterranean area via a deep shaft they constructed on Ellis Street. About 150 monitoring devices installed in the Powell Street Station and on neighboring buildings will provide live data feeds about tunneling conditions to web applications that the SFMTA, the contractor, BART and an independent panel of tunneling experts can view at all times. Similar devices are installed along the entire tunneling path, from 4th and Bryant in SoMa to Columbus and Powell in North Beach. The readings of these instruments and others on the TBMs themselves allow the tunneling contractor to respond rapidly to ground conditions around the machines as they move forward. ■

Robbins TBM completes boring at Turkish project

In December 2013, a 4.3-m (14.1-ft) Robbins double shield tunnel boring machine (TBM) emerged from boring a 9.3-km (5.8-mile) headrace tunnel in Turkey's Adana province for the Yamanli II hydroelectric project. The hard rock TBM broke through on time, due to excellent advance rates and minimal downtime for the duration of the project.

The machine, operated by contractor NTF Construction Co., reached high monthly advance up to 782.8 m (2,568 ft), with an average monthly rate of 472.7 m (1,551 ft) during the course of the 14-month project. Rates were achieved in ground conditions of mainly limestone with some clay-filled fissures. Average rock strength was 60 to 70 MPa, with a maximum strength of 120 MPa. Despite the hard ground, cutter expenses were kept low as a result of few replacements, proper cutter maintenance and a well-trained crew. Mustafa Akgül, tunnel chief at NTF Construction provided one such example: "The 28th gauge cutter ran more than 8 km (5 miles) throughout the bore in limestone up to 120 MPa without any change."

The machine also passed through two fault zones with clay inflows. At machine launch, only one fault zone was anticipated. Probing and pregrouting allowed crews to prepare in advance for the additional fault zone and other difficult ground conditions encountered along the way.

In addition to challenging ground, the machine also experienced unexpected power cuts. This led to delays resulting in long machine and PLC startups. Extended day and night shifts allowed the machine to catch up: "The machine performed very well with minimal downtime and made up the initial delays, finishing right on time," said Dursun Yıldız, machinery manager of NTF Construction.

Some modifications were required during machine operation, specifically the pea gravel conveyor system, bridge-front supporting legs, and the surveying system. Akgül spoke about the adjustments, saying, "Only three modifications were undertaken during [the bore], and Robbins Field Service conducted them smoothly. Their cooperation with NTF personnel was strong and continuous."

This Robbins 4.3-m (14.1-ft) TBM bored 9.3 km (5.8 miles) in Turkey.

The project took place at a remote jobsite roughly 200 km (124 miles) from the city of Adana. The mountainous region contains a valley, in which many civil works projects are currently taking place; the Yamanli II project is the third hydroelectric project in the area. The completed tunnel will source water from the Göksun River, with an annual generating capacity of 78 MW to power up to 78,000 homes. ■

Crossrail project tunneling progressing

It has been busy time in London, as numerous tunnel boring machines (TBM) have broken through on the Crossrail project.

The western tunnels of the £14.8-billion Crossrail project were structurally completed on Jan. 24 when the TBM called Adar broke through at Farringdon. This follows the arrival of her sister machine Phyllis at Farringdon in Oct. 2013.

In southeast London, another TBM, called Sophia, completed Crossrail's first tunnel beneath the Thames River, arriving at the North Woolwich Portal on Jan. 29.

The TBM named Jessica has also completed her tunneling journey from Pudding Mill Lane, breaking through into one of Europe's largest mined caverns beneath Stepney Green on Feb. 3.

In addition, tunneling machine Elizabeth made a spectacular entrance into the new Crossrail station at Whitechapel on Jan. 20 on her journey from Limmo Peninsula to Farringdon. Her sister machine Victoria also broke through into Stepney Green on Jan. 30, the Construction Index reported.

Contractors have also finished civil construction of the first of two new Bond Street station ticket halls. The western ticket hall on Davies Street is five stories underground, with works starting earlier on a passenger tunnel to connect the Crossrail ticket hall to the existing underground station.

Crossrail recently passed the halfway mark on time and within budget. This year will see the project transition from major civil engineering work to station and tunnel fit-out. There is now 30 km (18 mile) out of 42 km (26 mile) of bored tunnels complete. ■

SR 99 project could be stalled for months

The world's largest tunnel boring machine (TBM), Bertha, resumed its work on the SR99 Tunnel in Seattle, WA for approximately 0.6 m (2 ft) after a nearly eight-week delay but was again shut down because of above normal temperature readings coming from a seal area surrounding the main bearing of the machine.

On Feb. 10, Seattle Tunnel Partners (STP), which is building the tunnel, informed the Washington State Department of Transportation (WSDOT) that the delay could last months, as it works to find a solution for the machine.

"Replacing the seals is a complicated process and STP is working closely with Hitachi Zosen, the tunneling machine's manufacturer, to determine the best path forward," STP said in a release. "They are looking at two ways to access the seal area: through the back of the machine or by drilling an access shaft from the surface in front of the machine. Either way, this process will take months.

"STP has not yet fully determined the cause of the seal problems and, to date, they have not shown any evidence that suggests the state or taxpayers will be responsible for cost overruns associated with these repairs. We have requested and expect detailed plans on how the repairs will be made and how STP can recover lost time on the tunneling project," STP said in the release. "Since the machine is stopped and repairs need to be made, STP has also informed the city of Seattle that they can proceed with seawall replacement construction near the machine's current location."

The TBM stopped boring on Dec. 6. At the time it was reported that a buried pipe that got tangled in the face of the TBM was the reason for the stop. It has since been revealed that this was not the case.

In report published on Jan. 27 by the *Seattle Times*, Matt Preedy, deputy project administrator for the state Department of Transportation (DOT) said there were no major obstacles found in the soil or inside the rotating cutter.

With clearance to move forward the STP bored the additional feet needed to construct the next concrete liner ring.

In a statement published at its website, WSDOT said, "When the machine moved forward, crews saw indications of above-normal temperature readings in part of the machinery, similar to readings encountered before crews initially decided to stop mining on Dec. 6. STP made adjustments and mined an additional 0.6 m (2 ft). The above-normal temperatures persisted and STP made the decision to stop and perform further evaluations."

> **"Replacing the seals is a complicated process and STP is working closely with Hitachi Zosen, the tunneling machine's manufacturer, to determine the best path forward."**
>
> **Seattle Tunnel Partners**

With each week lost, the odds increase that the project will churn through the remaining $120 million or so in contingency funds for the tunnel project.

The state has already paid STP $774 million of its $1.44 billion contract to build the tunnel, ramps at both ends and road decks from Sodo to South Lake Union.

The original schedule called for Bertha to have just passed the Alaskan Way Viaduct by February, to enter the denser and more predictable soils deep below downtown Seattle.

Instead, the machine has 152 km (500 ft) left to go along the waterfront before it will pause in a "safe haven" of concrete for maintenance, just before diving under the old highway. The team has lost three months because of a glitch during tests in Japan, a labor dispute over who will load the barges and the recent shutdown. ■

New York's MTA gets $886 million in Sandy aid

A new influx of federal dollars will help mass transit across the U.S. Northeast region continue to rebuild 15 months after superstorm Sandy.

CBS New York reported that $886 million is coming to the MTA from a pot of $3.8 billion earmarked for the agency from the Federal Transit Administration.

"This funding will be used to help rebuild from the effects of Hurricane Sandy and to strengthen their system against future storms," U.S. Secretary of Transportation Anthony Foxx said.

About $535 million of the funding will go toward repairs of three tunnels under the river that were badly damaged in the Oct. 2012 storm — the Montague, Steinway and Greenpoint.

"Everyone saw the pictures of flood waters filling the subways. What may have been less visible was the havoc all that sea water wreaked on the electrical systems, signals and communications equipment," FTA administrator Peter Rogoff said. "We'll give back to the people of New York reliable access to jobs, school, doctors, friends, their place of business."

More than $103 million will fund projects to protect against flooding for Metro-North.

Federal officials said the money is keeping the promise to help rebuild stronger than before. ■

T&UC BUSINESS PROFILES

A special advertiser sponsored advertorial section

MARCH 2014

Underground Construction and Tunneling history is made by the investment of companies worldwide that dedicate their efforts and vision to the advancement of the industry.

SME and T&UC acknowledge these companies that demonstrate a continued focus on providing the world with the best in underground technology, products and services.

Makers of Underground History

JENNMAR

We're JENNMAR, a global, family-owned company that is leading the way in ground control technology for the mining, tunneling and civil construction industries. Born in 1965, by 1972 our mission had become focused on developing and manufacturing quality ground control products. Today we make a broad range of reliable products, from bolts and beams, to channels and trusses, to resin and rebar. We're proud to make products that make mining, tunneling and civil construction safer and more efficient. And with more than twenty manufacturing plants around the world, we are uniquely positioned to react to ground control needs anywhere, anytime.

A Single Source Provider

Our network of affiliates includes engineering services, resin and rolled steel manufacturing, custom steel fabrication, chemical roof support and sealing products, and even includes our own trucking company. This ability to provide a complete range of complementary products and services ensures quality, efficiency and availability resulting in reduced costs, reduced lead times and increased customer satisfaction!

Our Affiliates

J-LOK Resins (www.j-lok.com) - J-LOK manufactures state-of-the-art resin anchorage systems that are designed to complement JENNMAR products and provide an optimum bolt and resin system. J-LOK equipment is among the most technologically advanced in the resin industry.

JENNCHEM (www.jennchem.com)

JENNCHEM designs and delivers chemical roof support, rock stabilization and ventilation sealing products to the mining and underground construction industries. JENNCHEM's lab and test facility conducts meticulous and ongoing testing to ensure reliability and consistency of all products.

KMS (www.keystonemining.com)

KMS (Keystone Mining Services) is JENNMAR's engineering affiliate that provides advanced engineering services such as structural analysis, numerical and 3-D modeling. KMS is also responsible for conducting research and development of new products.

JENNMAR Specialty Products (www.jm-specialty.com)

JENNMAR Specialty Products provides custom steel fabrication services to the mining, tunneling and civil

construction industries. Products include Square Sets, Impact Resistant Arch Sets, Bent Arch Sets and Long Radius Arch Sets.

JM Steel (www.jm-steel.com)

JM Steel's ultra-modern 120,000 sq. ft steel processing facility is located on Nucor Steel's industrial campus near Charleston, SC. JM Steel has the processing capability and extensive inventory to provide a variety of flat rolled steel products including master coils, slit coils, blanks, beams, sheets, flat bars and panels.

JENNMAR continues to grow, but our focus will always be on the customer. We feel it is essential to develop a close working relationship with every customer so we can understand their unique challenges and ensure superior customer service. Our commitment to the customer is guided by three words; SAFETY, SERVICE and INNOVATION. It's these words that form the foundation of our business. It's who we are.

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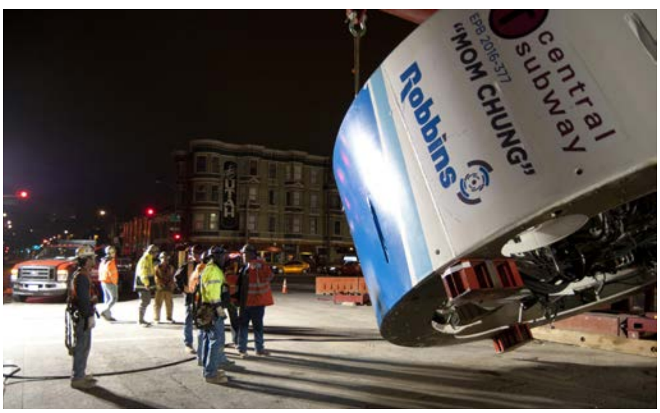
The Robbins Company

Industry Experts Committed to Innovation, Quality, and Support

With over 60 years of experience, The Robbins Company is the world's foremost developer and manufacturer of advanced, underground construction machinery. Robbins TBMs made swift headway on many worldwide projects in 2013, and will continue this progress in 2014. Innovative concepts keep expanding the company's scope, from efficient TBM assembly methods to high-performance machine designs resulting in landmark performances through both soft ground and hard rock.



Total Supply Company

Robbins is a total supply company, offering everything from cutters and stacker conveyors to knowledgeable field personnel and technical support. Robbins' time-saving Onsite First Time Assembly (OFTA) method was first used at Canada's Niagara Tunnel Project in 2006 and continues to be successfully carried out on multiple projects and with all types of TBMs. The method results in significant time savings and cost reductions for the contractor, all by initially assembling the TBM at the jobsite rather than in a manufacturing facility. At the Black River Tunnel in Lorain, Ohio, a massive 7.0 m (23 ft) Robbins Double Shield TBM and continuous conveyer system were launched in December 2013 (pictured above right).

Robbins' field service personnel bring years of engineering experience to each project. In mid-2013, personnel helped guide the transport of large TBM components through San Francisco, California's narrow and steep city streets. The team then oversaw the assembly and launch of two 6.3 m (20.7 ft) diameter Robbins EPBs in dense urban surroundings for the city's Central Subway project (pictured above left, photo credit: SFMTA). On the other side of the globe at Australia's Grosvenor Decline Tunnel, Robbins field service directed the onsite assembly of a unique 8.0 m (26.2 ft) Single Shield/EPB TBM for a coal mining tunnel. The hybrid machine was built in just over four months, and is making great headway as of February 2014.

Continued Success in Hard Rock and Soft Ground

Robbins EPBs continue to show their reliability and robustness, even in some of the world's most difficult ground conditions. Three 8.93 m (29.3 ft) Robbins EPBs are navigating very difficult ground for Mexico City's Emisor Oriente Wastewater Tunnel (pictured below left). Robbins Field Service and Engineering have worked closely with the contractor to maneuver the challenging geology, and strong machine performance is expected in 2014.

Robbins refurbishes many machines, and recently completed one such project for New York City's Harbor Siphon Project. The 3.6 m (11.8 ft) EPB was originally built by Caterpillar for the project, and began boring in 2012. Soon after, the entire tunnel and machine were flooded due to Hurricane Sandy in October 2012. One year later, the contractor turned to Robbins for repair work, which began in November 2013. Despite having no drawings or part numbers to refer to, Robbins successfully reassembled the machine ahead of schedule. It will be launched in February 2014 for the 2.9 km (1.8 mi) water tunnel.

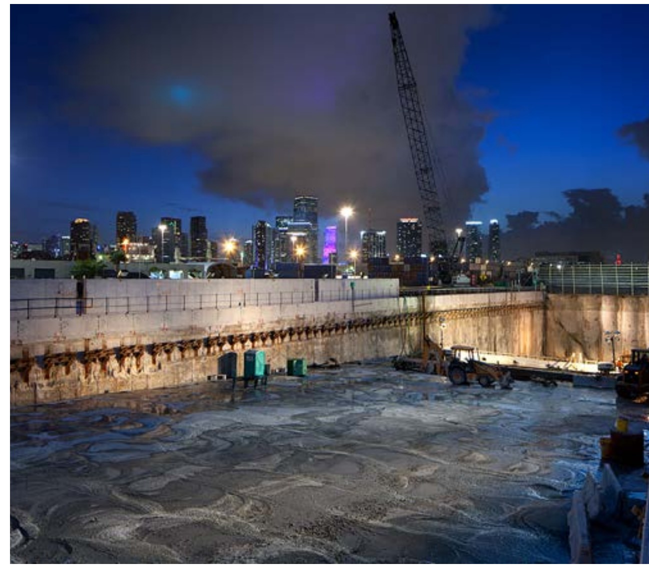
Robbins innovations will continue to advance in 2014, with major hard rock and mixed ground projects underway across North America, and spanning the globe. For further information on tunneling projects and groundbreaking R&D, visit www.TheRobbinsCompany.com or call +1 (440) 248-3303.

The Robbins Company
Telephone: +1 (440) 248-3303
www.TheRobbinsCompany.com

Leading the Way

Every structure needs a strong foundation and John Malcolm established Malcolm Drilling Co. Inc. (Malcolm) on a strong foundation of hard work, dedication and an unwavering commitment to pursue new technologies. Over the course of 50 years the company has become one of the country's foremost practitioner and authorities in deep foundation, retention systems and ground improvement work, operating the largest fleet of drilling equipment in the country (valued at more than $190 million). Malcolm is committed to reinvesting capital back into the company in the form of state of practice equipment and cutting-edge technology, which allows the company to serve client needs on a broad geographic basis.

Malcolm's list of core services as it relates to tunneling includes access shafts, excavation support systems, cutoff and secant pile walls, jet grouting, deep soil mixing, cutter soil mixing and dewatering. The company has augmented its construction and engineering expertise along with a strong safety record into an equally impressive resume that represents a significant number of high-profile, highly challenging tunneling projects throughout North America.

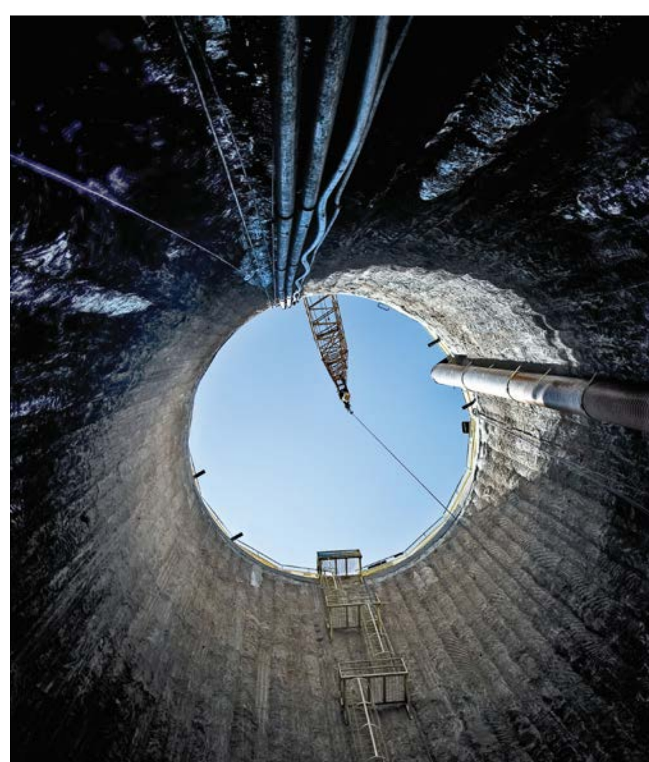


Malcolm crews recently completed work on the Alaskan Viaduct Replacement Project (SR 99), in Seattle where we installed the support of excavation (SOE) which incorporates large-diameter secant piles to construct the portal for Bertha, the world's largest tunnel boring machine (TMB).Various ground improvement techniques were used to construct several TBM Safe-Haven's in challenging glacial till with a myriad of undocumented obstructions. At the Port of Miami Tunnel Project in Florida, Malcolm installed the launch and retrieval pit for the TBM incorporating various Soil Cement Mixing techniques for the SOE as well as the break-in and break-out structures in highly permeable limestone. For the New Irvington Tunnel in California, we drilled very deep Secant Piles to construct the access shaft in rock with verticality requirements which until recently were unachievable.

Our large equipment fleet and highly skilled personnel affords Malcolm the unique ability to comply with the most rigorous schedule compression, while delivering a high quality product in the most difficult ground conditions. Our experience facilitates a Design/Build approach to projects and allows for timely collaboration with owners and contractors. We provide these services nationwide through our regional offices. We welcome the opportunity to work with you in developing the most efficient and cost effective solution to your next project.

Look to the Blue

Malcolm Drilling
www.malcolmdrilling.com



CDM Smith

CDM Smith provides lasting and integrated solutions in water, environment, transportation, energy and facilities to public and private clients worldwide. As a full-service engineering and construction firm, we deliver exceptional client service, quality results and enduring value across the entire project life cycle.

CDM Smith's underground construction staff includes geotechnical, structural, and civil engineers and geologists located worldwide. Our staff has extensive experience in providing the full range of tunnel and geotechnical related services. Our tunnel related work includes planning, feasibility and design, including both 2D and 3D FEM analyses. We offer construction services including construction and program management, inspection and geotechnical instrumentation monitoring and interpretation for soft ground and rock tunnels. Design and construction includes all types of ground modifications including ground freezing, grouting, and dewatering.

Our field equipment includes geotechnical instrumentation and construction data acquisition equipment. Our field personnel are NICET, OSHA and NRC certified. CDM Smith's tunnel services include:

- Shaft Design: Ground Freezing, Slurry Wall and Secant Pile Wall
- Conventional Soft Ground and Rock Tunnel Design, Microtunneling, Pipe Jacking and Directional Drilling
- Evaluation and Rehabilitation of Existing Tunnels
- Ground Investigation, Testing and Evaluations
- Groundwater Control System Design

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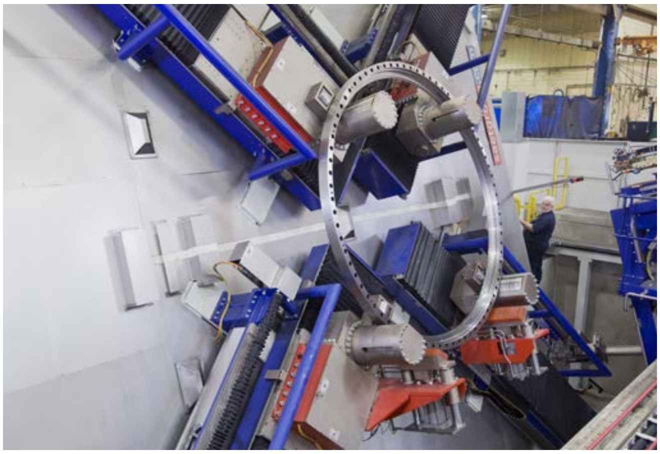
Messinger Bearings - A Kingsbury Brand



Messinger Bearings is one of an elite few companies in the world capable of producing large, custom-designed bearings for tunnel boring machines (TBMs). Messinger is addressing the challenge from end users who require new or repaired bearings of this size delivered in a reasonable timeframe.

TBM Bearing Customers Have an Option

Based in Philadelphia, Messinger Bearings was established in 1912 as a designer and manufacturer of large, heavy duty rolling element bearings. Today, Messinger focuses on providing large diameter custom bearings for unique applications, including those for TBM equipment. Messinger can manufacture new bearings to 25 ft in diameter, as well as repair them. In fact, Messinger is one of the few bearing manufacturers in the United States capable of turning and heat-treating bearings of this size completely in-house using a new state-of-the-art CNC vertical boring mill along with new induction heat treat capabilities.

New or Rebuild? Your Choice

Deliveries for 3-row TBM main bearings have been a recurring challenge for TBM customers. Messinger is committed to supporting its customers in its core business, that is, large heavy-duty custom bearings for specialty applications in limited quantities. In addition, Messinger maintains a repair and service department that is capable of rebuilding old bearings at a fraction of the cost of new.

For example, a TBM project was recently under way and the spare bearing was found to have a broken outer race. In addition to manufacturing a new outer race, Messinger was able to repair the entire bearing in more than enough time to have it on site when needed. Considerable savings were realized, not only with the repair itself but also by limiting downtime.

This is but one example of the problem-solving attention TBM customers routinely receive from Messinger Bearings -- to enable superior machine performance through expert bearing solutions.

MessingerBearings
A KINGSBURY BRAND

Messinger Bearings
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Telephone: +1-215-739-6880
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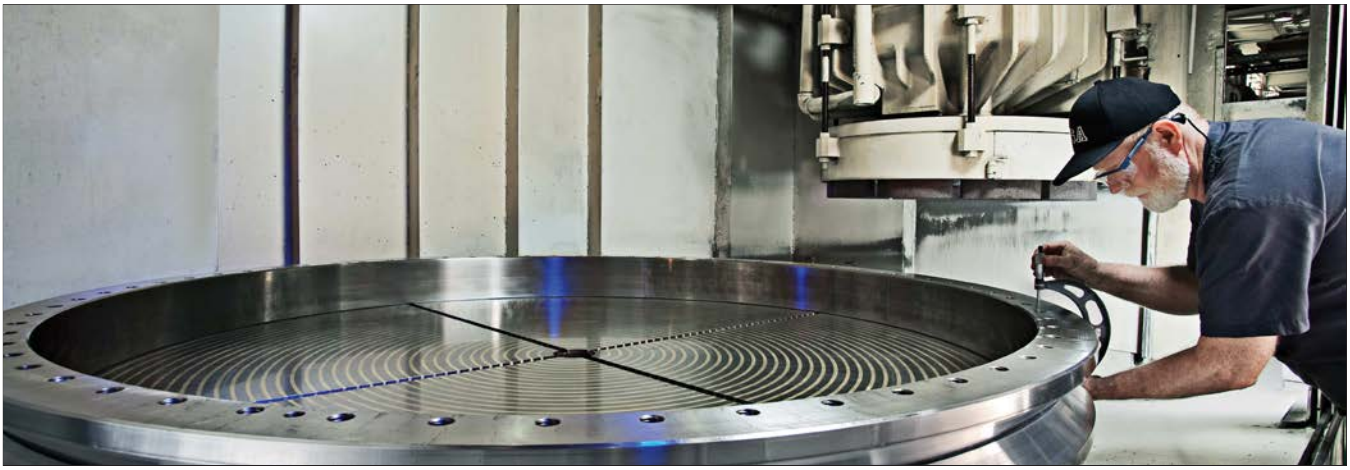



SPECIALISTS
IN TBM
BEARINGS.

The New York Blower Company

Our corporate mission is to be a world leader in manufacturing premium-quality, engineered fans and blowers to the industrial marketplace; fulfilling the need for reliable air movement and timely delivery. The New York Blower Company operates fan fabrication plants in LaPorte, Indiana, Leitchfield, Kentucky and Effingham, Illinois. International Subsidiaries fabricate our products in Manila, Philippines and Taiwan. NYB companies supply power utility and extra heavy-duty fan products from Medina, Ohio and Montreal, Quebec. Our fan designs provide the highest aerodynamic efficiencies compatible with specific systems and gas stream requirements. Durable fan structures are designed for long life in the harshest and most demanding industrial applications. We have also maintained an AMCA-registered laboratory that allows us to meet the highest standards in product development and product performance testing. All of our products undergo extensive air performance, sound and quality assurance testing prior to release to the market. That's why for the past 125 years, New York Blower has always had the right answer, even for the most demanding operations.

Our reputation of technical excellence is fueled by:

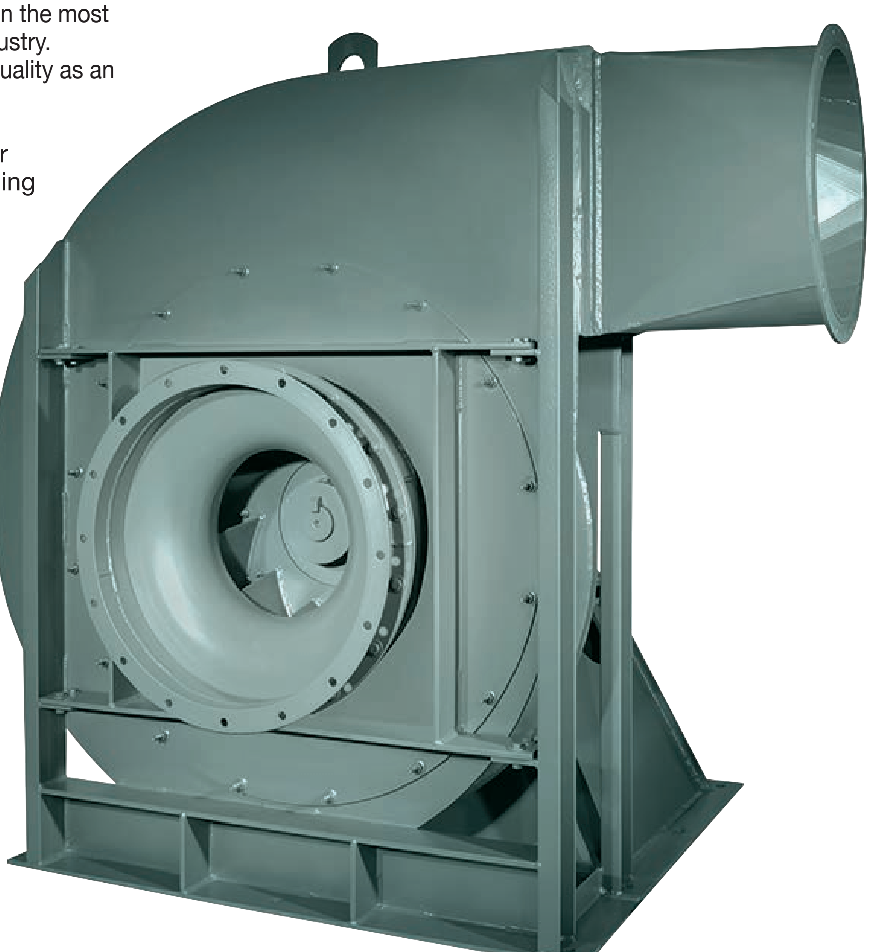
- Unmatched experience and manufacturing expertise.
- Consistent capital investment that results in the most modern equipment and facilities in the industry.
- Embracing the uncompromising product quality as an everyday, company-wide commitment.

Durable fan structures are designed for long life in the harshest and most demanding industrial applications. Both deep shaft and mining operations use a variety of New York Blower fans. Non-sparking below-ground applications use both axial and centrifugal designs for ventilation and safety exhaust-and-supply systems. Quarry trucks and draglines require cooling fans for the large DC traction motors. Crushing and grinding phases of ore processing use many types of New York Blower fans in environmental and ventilating systems. Some ore processing goes into a wet cycle where spray dryers and particle sizing systems direct products to chemical and food industries. New York Blower offers fans for all of these applications.

New York Blower has the experience, knowledge, and technology to produce what engineers and machine designers agree to be the most durable and efficient industrial fans and blowers. Today New York Blower has a worldwide presence with over 200 representatives, partners, and licensees established around the globe. We have maintained an AMCA-registered laboratory that allows us to meet the highest standard in product development and product performance testing. All of our products undergo extensive air performance, sound, and quality assurance testing prior to release to the market. So when it comes time to choose the best possible air-movement solution for your construction needs, trust the industry leader.

nyb Since1889 125 YEARS

New York Blower
Phone: +1-800-208-7918
www.nyb.com



Sterling Lumber Opens New 520,000 Square Foot Plant in Phoenix, IL

Sterling Lumber is expanding operations into their new 520,000 sq. ft., 60 acre facility in Phoenix, IL. The new facility will benefit its customers with increased production capacity, larger inventories, new manufacturing processes, cost control, faster delivery, and on-site heat treatment while continuing to provide exceptional customer service.

Sterling Lumber has four divisions: Crane & Access Mats, Construction Products, Crates & Pallets and its newest segment Temporary Road and Mat Installation. It has become a dynamic manufacturing company that provides products and services to the Transmission & Power Distribution, Oil & Gas, Wind, Coal, Hydropower & Geothermal, Heavy Construction, and Steel Industries.

The company's rapid growth during the last seven years has been achieved by manufacturing Matting for portable and temporary roads and work platforms throughout North America, as well as providing customers turnkey solutions to their Access Matting needs.

Sterling is currently consolidating three manufacturing plants and 117 existing employees into one new facility in Phoenix, IL and plans to add another 50 new employees over the next 24 months.

Long Proven History

In 1949, at the age of 41, Gerhard Sterling formed a scrap metal business in Northern Illinois. By 1970, Gerhard and his youngest son, John, had evolved the company into a successful lumber supplier.

Today, John and his four sons (Carson, Carter, Christian and Cooper) run a company built around six decades of consistency, quality and customer service. With warehousing, manufacturing, and sawmill locations in Illinois, Indiana, and Missouri, Sterling can deliver products coast-to-coast or internationally by truck, rail, or barge.

Providing Exceptional Customer Service

The key to Sterling Lumber's success has been its commitment to customer satisfaction with a personalized approach, based on timeliness, experience, accuracy and problem-solving effectiveness. The family invested into all aspects of the business and incorporated modern technology, inventory and adaptability with the company's core values of pride, hard work and trust.

Crane and Access Mats

Sterling Lumber builds the finest quality Crane Mats in the market, choosing only the best dense hardwoods from their timberland. The most important factor is the measure of safety that Sterling Lumber builds into all of their Matting products.

Products/Services:

- 30' – 40' Crane Mats
- Access Mats
- Barge Mats
- Carriage-Bolted Mats
- Excavator Mats
- Outrigger Mats
- Parts Mats
- Pipeline Skids
- Rig Mats
- Timber Mats
- Transition Mats
- Used Mats

Construction Products and Custom Crates & Pallets

Sterling Lumber keeps a massive inventory of lining lumber for earth retention walls, ground stabilization and shaft and tunnel. Lagging is available in pre-cut and standard dimensional sizes. The Sterling sawmills will prepare any specified lengths and widths required.

- Blocking Lumber & Dunnage
- Commercial Lumber
- Lagging
- Pre-made Lagging Panel
- OSB, Plywood, Forming Plywood and Sheathing
- Shaft and Tunnel Lagging
- Shielding
- Tunnel Lagging & Ties
- Wedges -- Support Saddles
- Pipeline Skids
- Timbers and Piling
- Heat Treated Lumber

Temporary Roads, On-Site Mat Installation, Extraction and Removal Service

Sterling's Matting products are used for a variety of applications from temporary roads to rig-site platforms, simplifying access to remote locations, protecting sensitive terrain from damage, and reducing reclamation costs. Sterling has the ability to customize to any environment or application while providing the most cost-effective, access solution service.

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Email: sales@sterlinglumber.com
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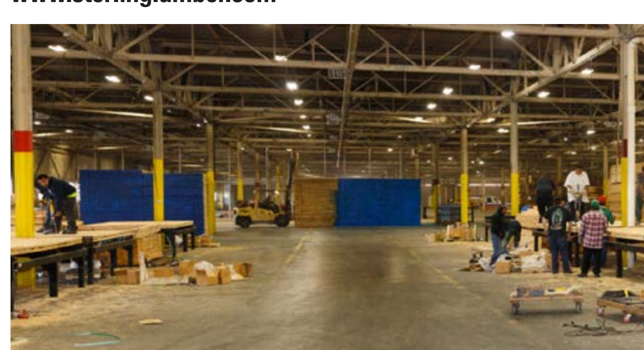
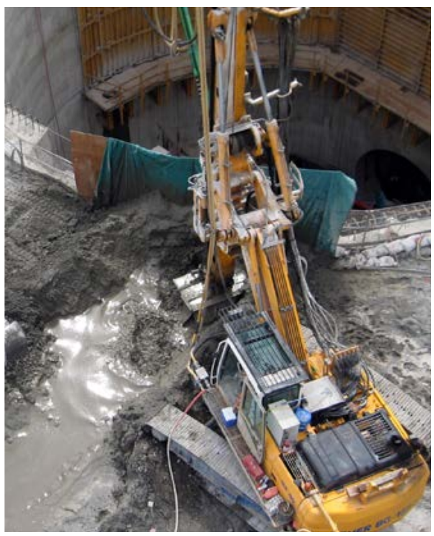


North America's Leader in Geotechnical Construction

Hayward Baker handles geotechnical challenges both large and small. Our extensive experience with the full range of ground modification techniques has been applied to hundreds of tunneling projects. Commonly applied tunneling services include earth retention, underpinning, waterproofing, soil improvement, and ground stabilization.

Seattle, WA
Brightwater Conveyance System

Construction of the Brightwater Conveyance System required surgical jet grouting to facilitate tunneling operations. Utilizing their proprietary jet grouting equipment, Hayward Baker created soilcrete blocks outside of four deep vertical shafts to assist with both TBM and hand-mined tunneling operations. The ground improvements allowed TBMs to be launched or received into and out of the shafts without the risk of water and ground run-in. Overlapping columns to depths of 94 feet compose the soilcrete blocks.


Brightwater Conveyance System

Los Angeles, CA
Lower North Outfall Sewer Rehabilitation Project

Rehabilitation of the 82-year-old Lower North Outfall Sewer included grouting around the outside of the tunnel to densify and strengthen the soil above the tunnel in order to protect the overlying structures from settlement. Hayward Baker performed permeation and fracture grouting through over 3,500 holes from within the tunnel, stabilizing the overlying structures. State-of-the-art survey technology and proprietary grouting instrumentation allowed Hayward Baker to first probe the soil to determine existing conditions, and then observe the soil response during grouting, while monitoring the ground surface in real time.


Lower North Outfall Sewer

Los Angeles, CA
Metro Gold Line C800

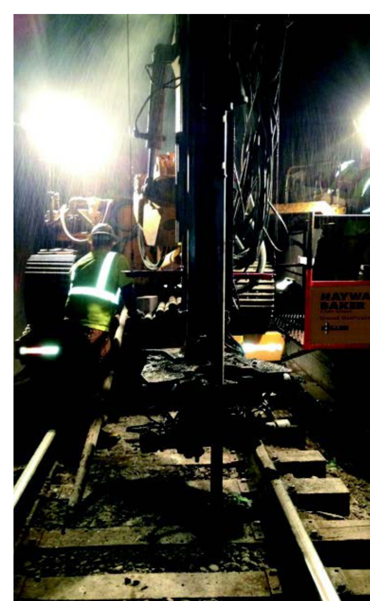
Construction of twin subway tunnels for the LA Metro's Gold Line would cause ground loss, endangering overlying structures unless the soils surrounding the tunneling zone were treated prior to excavation. Using conventional horizontal drilling to install steel and PVC sleeve port grout pipes, Hayward Baker performed chemical grouting to stabilize soils, and fracture grouting to protect overlying structures. Heave and settlements were monitored by exterior remote robotic total stations and interior wireless tiltmeters.

St. Louis, MO
Baumgartner Tunnel Alignment

Water-bearing rock formations in the path of the Baumgartner Tunnel Alignment needed to be sealed. Unsafe levels of hydrogen sulfide forced the grouting to be performed from the surface in advance of the tunneling operation. Hayward Baker drilled and grouted the water-bearing rock formations along a 1,200-foot-long segment of the proposed 20,000-foot-long, 12-foot-diameter combined sewer tunnel. A total of 40,000 feet of grout holes was drilled to complete the project. Depths of the drill holes were approximately 170 feet from ground surface.

Big Bend Tunnel Improvement
Big Bend, WV

Big Bend rail tunnel, constructed in 1932, required extensive ground and wall improvements over a 1,200 foot stretch due to its age and frequent use. Hayward Baker stabilized the tunnel walls with cement-bentonite structural grout, several rows of rock bolts and dowels, and compaction grout underpinning. Epoxy and cement grouting were utilized to repair an existing fracture of the tunnel liner along the spring line. Hayward Baker also stabilized the invert with compaction grouting at approximately 4,000 locations.


Big Bend Tunnel Improvement

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Telephone: +1-410-551-8200
Fax: +1-410-799-3786
www.HaywardBaker.com

Alpine Equipment

Alpine Equipment is the industry leader in hydraulic rock and concrete grinder attachments, roadheaders, shaft sinkers and soil remediation equipment, with over 40 years of expertise in North America. Our customers range from owner-operators to the largest tunneling firms. Alpine supplies attachments for construction, demolition, excavation, scaling, trenching, mining and tunneling. The rotary cutter heads come in range of sizes to fit on skid steer loaders, backhoes and excavators or any equipment with a hydraulic circuit. With a range of options and customizations, we can get you working more efficiently and with more precision than your current tools. Many of our customers are using the cutter head for concrete scaling projects for highway rehab or shotcrete clean up. The power, flexibility and precision of the Alpine concrete grinder enable this as a highly useful tool in a variety of jobs.

In addition to rotary cutterheads, Alpine also supplies state-of-the-art in situ soil mixing and remediation equipment. Remediation equipment includes mixing attachments and wet or dry amendment delivery systems.

With increased Natural Gas production, we have supplied the industry with mixers for solidification of drilling mud, whether on site or in container batches. The power and efficiency of our mixers have yielded significant production increases, allowing you to reduce costs and finish on time.

Contact Alpine Equipment for cutterheads, new & used roadheaders, ITC tunneling machines and soil mixing equipment.

Telephone: +1-814-466-7134
Email: info@alpinecutters.com
www.alpinecutters.com

Moretrench

Moretrench, headquartered in Rockaway, New Jersey, is a full-service geotechnical contractor specializing in design/build and turnkey solutions for challenging construction requirements and subsurface conditions. The company's wide range of services includes construction dewatering and groundwater control; ground/water treatment; mass and peripheral ground freezing; jet, permeation, compaction, compensation and fracture grouting systems; cut-off and containment systems; earth retention and excavation support systems; underpinning and foundation support; deep foundations; environmental remediation, including landfill gas and leachate systems; and specialized civil and mechanical construction. These services are available nationwide through full service offices in New Jersey, New York, Tampa and Orlando, Florida, Massachusetts, Pennsylvania, Delaware, Maryland, Wisconsin and Iowa.

For unanticipated problems such as abrupt building settlement, retention wall movement, high-volume groundwater inflow, contaminated water supplies, gaps in "bathub" excavation support, under-dam seepage and sinkholes, Moretrench offers a 24-hour emergency response service.

Moretrench is a member of the USGBC (United States Green Building Council) which oversees the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the USGBC to provide standards for environmentally sustainable construction.

Moretrench
Telephone: +1-800-394-MORE
www.moretrench.com

Putzmeister Shotcrete Technology, Your Worldwide Partner for Quality and Innovation

Putzmeister Shotcrete Technology provides you with one source for the world's most complete offering of solutions and equipment for sprayed concrete.

Since purchasing Allentown Equipment with its more than 100 years of shotcrete expertise, and combining it with Putzmeister's innovative concrete technologies and experience, Putzmeister Shotcrete Technology can provide world-class support for contractors' needs in the Refractory, Underground, Mortar and Civil industries.

In the early 1900s, Allentown's pioneering technology was first developed for taxidermy purposes when its originator Carl Akeley, a famous hunter and professor, devised a method for spraying plaster onto a wire frame. The outcome was a strong, thick plaster coating that didn't slump from the frame or set before being fully placed.

Forty years later, a new process was developed involving the use of pressure tanks to force stiff mortar through a hose. This new wet-process became known as shotcrete - and the rest is history.

"In this day and age, very few companies are able to succeed in business for over 100 years," says Patrick Bridger, president of Putzmeister Shotcrete Technology. "We are very proud of our longevity, and see it as a testament to our reputation for quality, and the value we have brought our customers for more than a century."

Mixkret 4 - Low Profile Concrete Mixer

Since the 1950s, the Allentown name has been synonymous with the process of spraying mortar at high velocity onto surfaces in the refractory, underground, mortar and civil industries. The equipment line has expanded to include a wide range of Gunning Machines, Pre-dampeners, Dosing Pumps, Pumps, Combination Mixer-Pumps, Mixers, Chemical Additive Pumps, Nozzle Carriers, Mortar Machines, Concreting Machines and parts and accessories.

Throughout the years, numerous milestones have been achieved:

- 1900s - Carl Akeley develops method for spraying plaster onto wire frames.
- 1910 - First Cement Gun introduced at New York Concrete Show.
- 1911 - Patents and trademarks issued for the Cement Gun and its Gunite process.
- 1950s - Wet-process shotcrete application developed.

SPM 307 Nozzle Carrier

- 1960s - Dry-process rotary gun developed.
- 1970s - Swing-tube technology used on wet-process shotcrete equipment, making application and use more practical.
- 2007 - Company acquired by Putzmeister America, Inc., resulting in most comprehensive line of sprayed concrete equipment. Name changed from Allentown Equipment to Allentown Shotcrete Technology, Inc.
- 2008 - Allentown becomes exclusive United States distributor of the Sika/Aliva family of wet- and dry-process shotcrete equipment.
- 2009 - Putzmeister America's Special Application Business forms partnership between Allentown, Esser Pipe Technology and Maxon Industries, Inc., creating a comprehensive systems approach for tunnel and mining, dam and power generation, transportation, marine and off shore projects. MacLean Engineering, in partnership with Allentown, develops new self-contained shotcrete spraying machine.
- 2010 - Allentown Celebrates 100th Anniversary.
- 2012 - Allentown Shotcrete Technology, Inc. is re-branded Putzmeister Shotcrete Technology.

With Putzmeister's reputation for excellence and expertise built on our commitment to application-oriented engineering and customer service – put the strength of Putzmeister to work for you. Contact us at (800) 553-3414 or visit PutzmeisterShotcrete.com.

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SPM 500
Dulles Corridor Metrorail

Local Presence. Global Competence.

DSI Underground Systems offers a complete selection of ground control solutions for the Civil, Mining and Foundation markets. We have been a leader in the underground support business in North America since 1920.

We are a global leader in tunnel and shaft construction, focused on engineered and tailored products to support our customers and industry.

DSI is proud to bring an expanded group of products to the job site:

- Aliva/Sika – Shotcrete Products
- ALWAG – Support Systems
- Biomarine – Tunnel Rescue Equipment
- Boart – Probe and Roof Bolting Equipment
- CBE – Segment Moulds – Precast Segment Moulds, Related Equipment & Plants
- ChemGrout – Grouting Equipment
- Condat – Ground Conditioning Chemicals and Lubricants
- Cooper & Turner – Bolts and Sockets for Precast Segments
- Montabert – Excavator Drilling Attachments & Replacement Drifters
- Dywidag – Bolts and Accessories including DSI Threadbar, Friction Bolts and Omega Bolts
- ES – Rubber Segment Gaskets
- Geodata – Monitoring Equipment
- Hány – Grouting Systems
- Promat International – Fire Protection Products
- Tunnel Tec – TBM Cutting Tools
- Vik Orsta – CT-Bolts – Double Corrosion Protection
- Weldgrip – Fiberglass Bolts and Dowels
- WIRTH – TBM, Pile Top Rigs
- ACI – Steel Ribs, Liner Plates, Lattice Girders, Lagging and Miscellaneous Support Items
- ACI – Tunnel Fabrications and Accessories

DYWIDAG-SYSTEMS INTERNATIONAL

DSI

DSI Underground Systems, Inc.

Telephone: +1-276-466-2743
dsiunderground.com

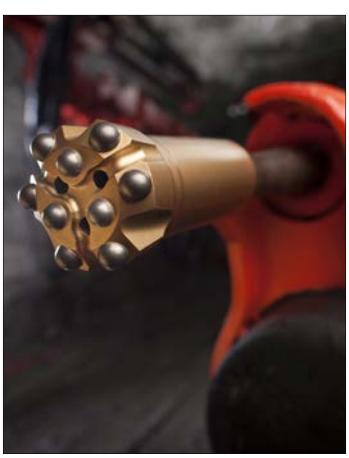
Sandvik in Tunneling

Sandvik tunneling expertise covers a variety of methods: Drill and blast, mechanical cutting and breaking. The equipment range includes tunneling jumbos, roadheaders and cutting units, bolters and bolts, drilling and cutting tools, hydraulic breakers, loading and hauling equipment, mobile crushers, and financing, parts and consumables, training, technical support, and repair and rebuild service.

The Sandvik DTi series of intelligent tunneling jumbos are fast, accurate and user-friendly. The series is available in four models for excavation of 12–211 m^3 cross sections, including face drilling, bolt hole drilling and mechanized long-hole drilling.

Sandvik rock tools offer straight holes, high penetration rate and low costs per meter. As the only supplier with in-house resources for cemented carbide production and R&D as well as drill steel production and R&D, Sandvik can control the whole supply chain from raw material to finished products.

Sandvik roadheaders are extremely powerful, robust rock cutting machines that let you focus on the essential: breaking on through to the other side. These roadheaders are designed to excavate roadways, tunnels and underground chambers without using explosives that can cause harmful vibrations. This is highly valued for both environmental and safety reasons, making roadheaders extremely suitable for underground construction in urban areas.



Research & Development

In order to ensure the best solutions, Sandvik has specialized R&D centers for different fields of rock excavation. Sandvik also works in close cooperation with universities, research institutes and specialist associations everywhere in the world. As results of these R&D projects, Sandvik now offers an energy saving cutting system for roadheaders, a new roadheader type equipped with state-of-the-art profile control and automatic sequence control systems, as well as the DTi jumbos with iSURE® process optimization tool software – just to name a few.

Sandvik Cutting Technology Center runs its own in-house cutting test laboratory, addressing particular customer requirements and offers the latest solutions in mechanical cutting for all kinds of soil and rock. In addition, Sandvik has specialized R&D centers for Drilling Control, Rock Drill and Drilling Tools technologies. Sandvik is also the only manufacturer in the industry owning a unique test mine for practical testing in real life conditions.

Cleaner and safer tunneling

Sandvik focuses on continuously developing novel tunneling methods, making equipment safer, more efficient and more productive, giving results of the highest quality. As a key core value, Sandvik engineers are committed to safety, constantly developing solutions to offer a protective working environment, with efficient ergonomics. All Sandvik production operations are ISO14001 and ISO9001 certified.

Intelligent Solutions

Sandvik iSure® tunneling excavation management tool is designed for the people on site. Revolutionary in its approach - iSure® uses the most critical spot, the blast plane, as basis for the whole planning process. As a result, hole locations and blasting, are optimized. This translates into excellent accuracy, fast process and large-scale savings.

Find out more about Sandvik Tunneling offering on www.understandingunderground.com

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Smyrna, GA, 30082
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Email: info.smc-us@sandvik.com
www.construction.sandvik.com

HNTB: Innovative tunnel solutions for a city-centric world

The trend of people moving to more heavily populated urban areas is fueling demand for additional infrastructure in major cities that are challenged to develop adequate supporting infrastructure and facilities. Urban growth is exerting increased demand for more efficient transportation, reliable power, water and wastewater conveyance, and communication systems. Many cities are opting to add infrastructure underground. Modern technology makes that solution possible and preferable. Impressive, sophisticated underground structures can help solve current and future urban congestion and development challenges.

University Link Tunnels under I-5 in Seattle

HNTB Corporation has more than 45 years of experience in the design, construction and restoration of tunnels and underground structures in various grounds in the highway, transit, rail, aviation and water resources markets. Among its recent notable projects are:

- The Alaskan Way SR99 Tunnel in Seattle
- Tom Lantos Tunnels at Devil's Slide in California
- Istanbul Strait Road Crossing in Turkey
- Midtown Tunnel in Norfolk, Virginia
- Amtrak's B&P Tunnel in Baltimore
- Crenshaw-LAX subway line in Los Angeles
- Structural assessment and rehabilitation of several subway tunnels and stations in New York in the aftermath of Super Storm Sandy

HNTB provides full service in tunneling and underground engineering including:

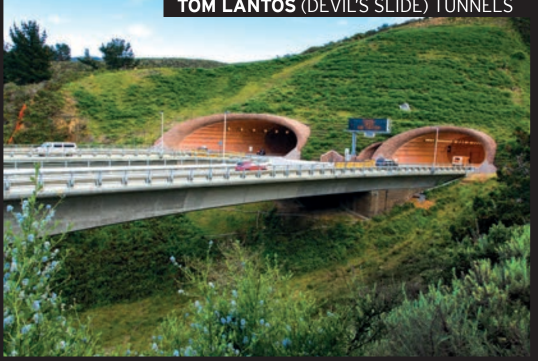
- Program and construction management
- Design of soft ground tunnels, rock tunnels, caverns, shafts, New Austrian Tunneling Method, cut-and-cover structures, immersed tunnels, micro-tunneling and pipe jacking
- Condition survey and rehabilitation
- Geotechnical and engineering geology
- Excavation support, protection of existing facilities, and underpinning
- Settlement analysis and mitigation
- Seismic design and retrofit
- Geotechnical and structural instrumentation
- Ground improvements and groundwater control
- Tunnel ventilation and fire-life safety design
- Tunnel security and hardening

HNTB
www.hntb.com

Tom Lantos Tunnels in California

COMPREHENSIVE
TUNNEL AND UNDERGROUND ENGINEERING EXPERIENCE

- Winner of the 2012 International Tunneling Award Tunneling Advisor/Program Manager of the Year
- Longest road tunnel in California
- First to use NATM in California
- First tunnels to use LRFD



TOM LANTOS (DEVIL'S SLIDE) TUNNELS

ALASKAN WAY TUNNEL

- Largest TBM tunnel in the world
- Largest double deck tunnel in the world
- State of the art design and construction

For more information, please contact:

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szlatanic@hntb.com

HNTB

The HNTB Companies
Infrastructure Solutions

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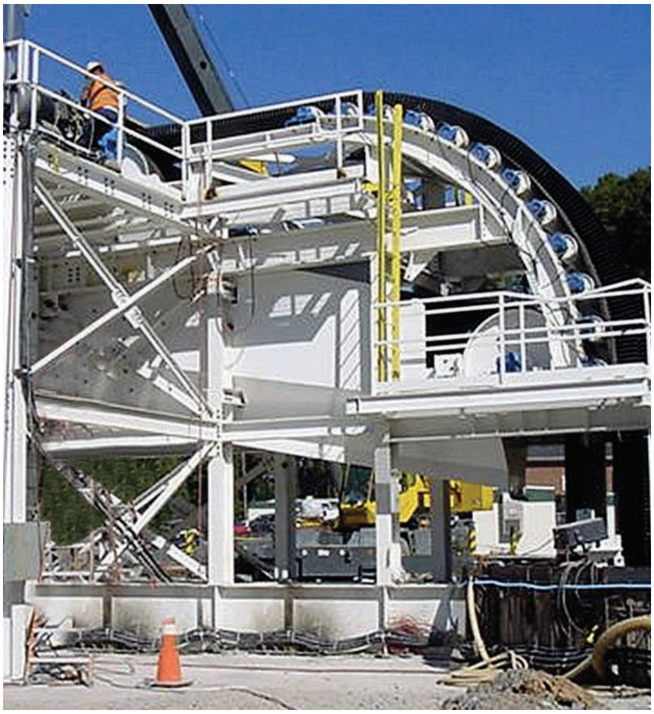
FKC-Lake Shore

FKC-Lake Shore serves the underground heavy civil and mining industries throughout North and South America. We offer design-build-install services for innovative hoisting, elevator, and vertical conveyance systems used to transport personnel and material. Our Field Services Division provides routine maintenance, inspections, wire rope NDT, and 24/7 emergency repair of electrical and mechanical systems.

Products/Services:

- Vertical Belts
- Skips
- Hoists
- Sheaves
- Elevators
- Cages
- Headframes
- Brakeman Cars
- Controls
- Field Services
- Wire Rope NDT



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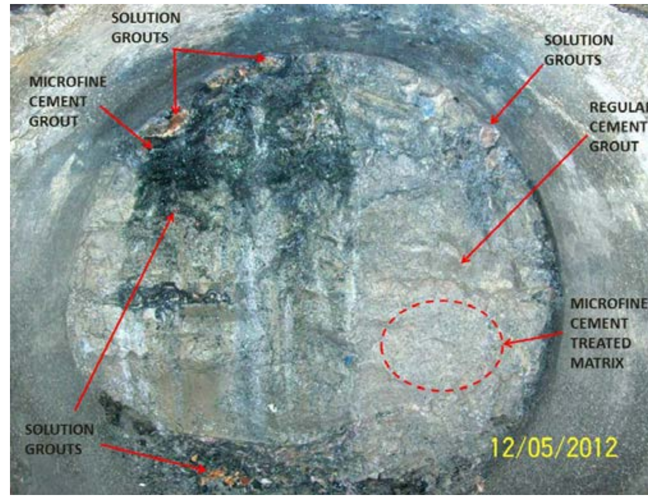
TBM Under Ocean Waters – AvantiGrout to the Rescue

Build it and they will come! That was the government's mantra to attract larger ships into the Port of Miami. However, the existing channel between Fisher Island and Miami Beach was too shallow. In order to deepen the channel, an aging sanitary sewer main belonging to the Miami-Dade County Water and Sewer Department had to be lowered.

The new sanitary sewer main consists of a 54 inch HDP pipe located approximately 100 foot below the ground surface for approximately 850 linear feet. This successful design-build shaft and tunnel project was led by Ric-Man Construction (Ric-Man). An experienced contractor like Ric-Man recognized immediately that groundwater would cause problems for underground construction in and under the ocean waters of the Atlantic. Ric-man hired ECO Grouting Specialists (ECO) to design and direct a pre-excavation grouting program to facilitate the construction of three shafts planned to access the new sanitary sewer alignment tunnel. The shafts, constructed using 100 foot plus deep secant piles, were situated both on land and in the channel. The planned tunnel would be six feet in diameter.

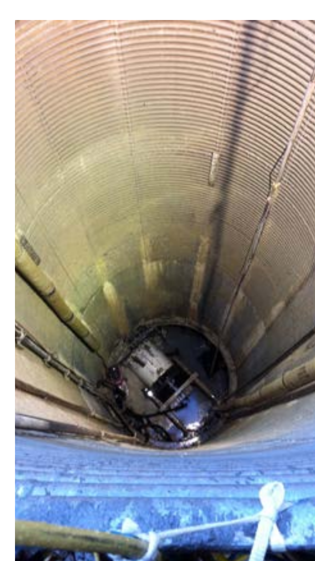
The geology of the area consisted of highly variable porous soft limestone, coral and silty sand. ECO developed a specially formulated grout to treat these highly variable soils and rock strata prior to the secant pile installation to provide groundwater control. This pre-excavation grouting was very successful. Upon completion, the TBM was assembled in the shaft and prepared to launch through the shaft wall. During the break-in, the geology was not as competent as expected and groundwater inflows



of 500+ gallons immediately flooded the TBM and shaft halting tunnel construction. ECO was again called upon by the Contractor to reduce the water inflow around the TBM to a manageable inflow that would allow for the break-in to occur and the tunnel liner to provide a water seal. This was a formidable grouting challenge because the TBM could not be locked in place with the grout.

The solution? A solution grout, AV-160 Acrylate by Avanti International. From previous grouting experience, it was known that the existing geologic formation was amenable to cementitious grouts, however this type of grout would provide a greater risk to grouting the TBM in place. The strength characteristics of the AV-160 were perfectly suited to encapsulate the TBM, providing a protective shell from the cementitious grout. To seal the water beyond the AV-160, Ultrafine Cement from Avanti was used to grout the erratic geology effectively sealing the water off. To accomplish this grouting procedure, various sleeve pipes were installed and packers were used to deliver the grout to isolated stages of the geology.

The grouting operation was continuously monitored with CAGES (Computer Aided Grouting Evaluation System), a real-time monitoring system, and the permeability of the subsurface was reduced to target values which reduced the inflow to less than 5gpm. The careful selection and use of the Avanti grouts allowed for the tunneling operation to resume and successfully complete the tunnel.



Avanti International
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Telephone: +1-800-877-2570
www.avantigrout.com

Itasca International, Inc.

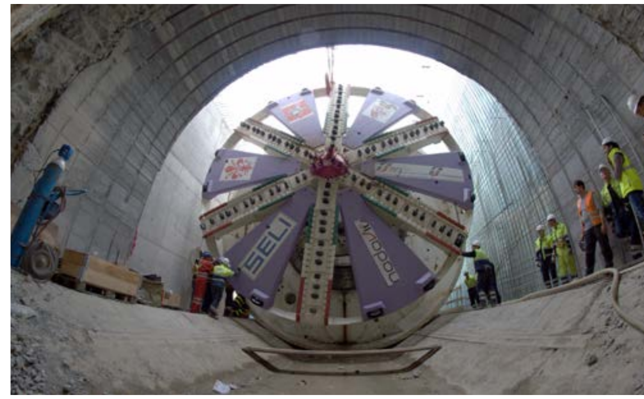
Who is Itasca?

As the world leaders in geomechanics, hydrogeology and microseismicity, Itasca consultants solve problems in civil engineering, mining, oil and gas, manufacturing and power generation.

What Does Itasca Do?

Itasca approaches all assignments with a solid background in civil engineering and an extensive knowledge of state-of-the-art design, numerical modeling and analysis techniques. Together these strengths allow us to provide innovative, practical solutions to a wide array of projects. Civil engineering problems involving soil mechanics, rock mechanics, soil-structure interaction, rock-structure interaction or coupled rock/soil-hydro-thermal effects are the basis of Itasca's work in an extensive range of projects, including highway tunnels, deep foundations, slope stability, shoring, utility tunnels, hydroelectric plants, subway systems, dams and retaining structures. Our experience has been recognized internationally by engineering societies, universities and our own clients.

In its 30 year history, Itasca has expanded from one office in Minneapolis, Minnesota to 14 offices in 11 countries. Staff in our international offices have developed expertise particularly suited to their respective regional conditions and client needs. This allows Itasca to offer advanced, first-hand knowledge of the particular civil engineering challenges in each region and a collective pool of expertise that covers important engineering services. The diverse background of Itasca personnel ensures that we are thoroughly familiar with typical design and construction issues and uniquely equipped to attack challenging or non-standard problems, while providing practical solutions. Because civil engineering rules and techniques vary from place to place, technologies practiced in one country often are not available in another. The shared perspective developed across Itasca's international offices broadens our civil engineering capacities by bringing these innovative and emerging technologies to new geographical areas.

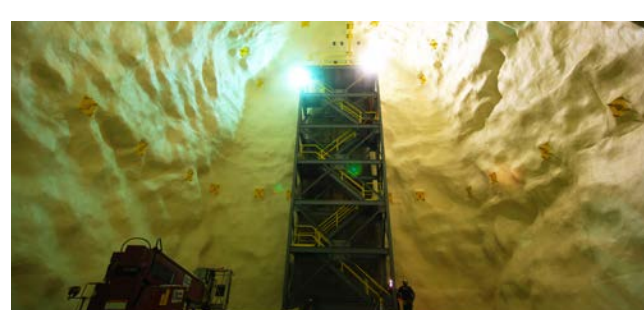


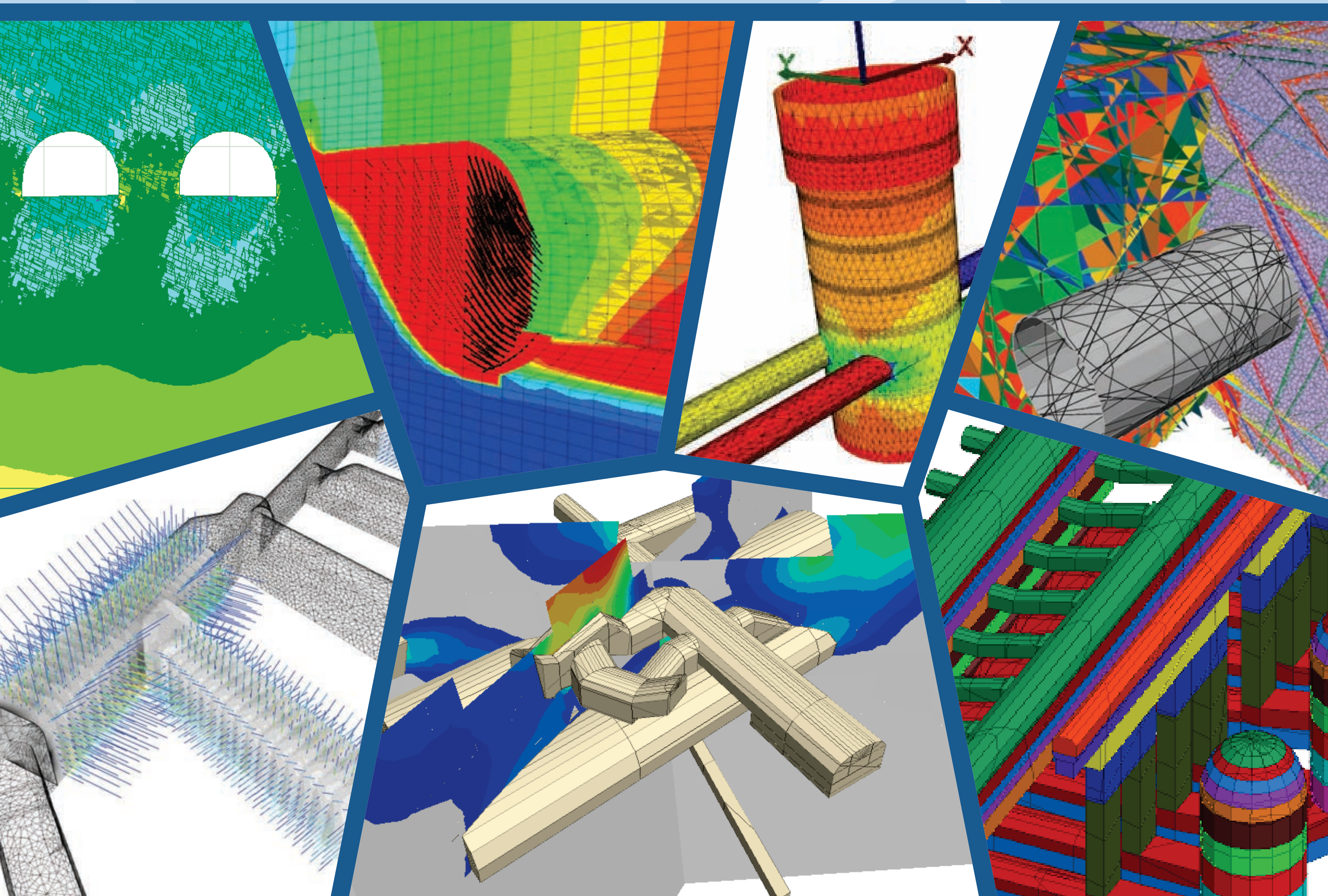
We also apply our software to field problems where standard technologies may be insufficient for successful problem resolution. Itasca maintains a diverse, accomplished, staff of engineers across all aspects of civil engineering from the practical to the theoretical, including coupled hydromechanical processes, soil and rock reinforcement/support and dynamic analysis. Itasca can assist clients in building and reviewing models for their own use, or we can perform the complete analysis. Itasca offers engineering during construction to check predicted performance.

Please contact us if we can assist you in the following areas:

- Large caverns in rock
- Rockfill and concrete dams
- Surface excavations
- Cut slopes
- Earth retaining structures
- Harbor structures
- Foundation design in soil and rock
- Slope stability
- Tunnel support and design
- Dynamic analysis of dams and other structures
- Evaluation of liquefaction potential
- Groundwater flow and dewatering
- Heat transfer
- Design reviews
- Soil improvement
- Monitoring and instrumentation
- Water-well designs

Itasca International, Inc.
Minneapolis, MN
Telephone: +1-612-371-4711
www.itascacg.com





Mining Equipment Ltd.

12-ton explosion proof diesel locomotive pulling 8 cubic meter side-dump muck cars out of the tunnel.

Mining Equipment has been supplying the mining and tunneling industries with top quality rolling stock for more than 30 years. They supply diesel and battery locomotives up to 35 tons. As well as a complete line of non-propelled rolling stock including muck cars, flat cars, personnel cars, segment car and concrete agitator cars.

Recently Mining Equipment has supplied a string of rolling stock including 5th wheel dump muck cars to Stillwater Mining in Montana. The cars will be used to haul muck out of a new TBM mined tunnel.

Another recent project for Mining Equipment was the New Irvington Tunnel in northern California. 12-Ton explosion proof diesel locomotives were supplied as well as a large spread of 5th wheel dump muck cars, flat cars and personnel cars.

Mining Equipment is based in Durango, Colorado. There primary shop is in Farmington, New Mexico. They also have a fabrication facility near Shanghai, China and an office in North Bay, Ontario.

25-ton diesel locomotive pulling a string of 15 cubic meter capacity roll-over muck cars through a dump at their mine in Papua New Guinea.

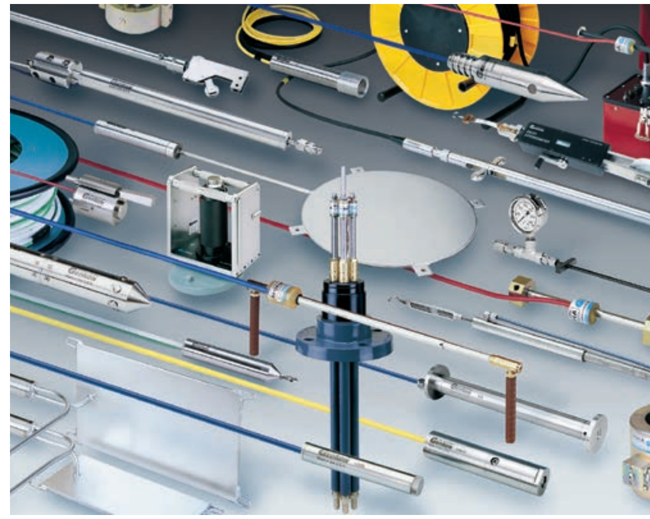
Mining Equipment Ltd.
Telephone: +1-970-259-0412
Fax: +1-970-259-5149
www.miningequipmentltd.com

Geokon, Incorporated

Geokon, Incorporated, is a 35 year-old company based in Lebanon, New Hampshire, USA. It operates on a worldwide basis through a network of over 45 agencies for the manufacture and sale of geotechnical instruments. Founded in 1979, Geokon currently has over 100 experienced employees, many of whom have been with the company for over 25 years. Geokon, Inc. has emerged as The World Leader in Vibrating Wire Technology™ and one of the major global instrumentation companies due to our high-quality products, responsive customer service and industry-leading designs.

In addition to almost all major cities in the USA, our instruments have been used in tunnels and subway systems around the world, including those found in Seoul, Taipei, Guangzhou, Istanbul, Hong Kong, Singapore, London and the Channel Tunnel.

Tunnel-specific instruments include NATM-style concrete pressure cells for monitoring stresses in shotcrete linings; convergence meters and tape extensometers to measure tunnel closures; multiple-point borehole extensometers and instrumented rockbolts to monitor the stability of the surrounding ground; piezometers to monitor ground water pressures and displacement gages to measure movements across cracks and joints. Dataloggers are used to take readings at programmed intervals and transmit real-time data (and any triggered alarm signals) to local stations or to remote readout locations using web-based software.



Geokon's experienced staff is at your disposal to assist in instrument design, selection and installation. For more information please visit www.geokon.com, e-mail us at info@geokon.com or call 1-603-448-1562 and speak to a sales representative.

Geokon, Inc.
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Premier Pipe Systems Manufacturer for over 85 Years

Since 1925, Naylor Pipe Company has been the premier manufacturer of Spiralweld pipe systems.

Naylor Spiralweld is available in diameters from 4” through 96” and wall thickness from 14 Ga. through 1/2” wall. The Spiralweld pipe is complemented with all types of fittings, fabrications to specification, and joint connections, including the exclusive Naylor Wedgelock Coupling, to complete your pipe system.

Naylor Spiral Buttweld pipe features two welds along the spiral seam. This creates a pipe structure in which the weld is as strong or stronger than the parent metal.

The Naylor manufacturing process creates a pipe that maintains an accurate diameter throughout its length. The uniformity of the pipe ends speed connection, whether mechanically coupled or welded.

Uniform wall thickness is assured because tolerances of steel strip are governed by the standards established by the American Iron and Steel Institute. In addition, the pipe is furnished in any required length with a cutting tolerance of plus or minus 1/8”. In addition to carbon steel, spiralweld pipe can be formed from many steel grades, including abrasion resistant, weathering (A-588) and stainless.

Every length of Naylor Pipe is inspected and where required hydrostatically tested to applicable ASTM specifications. The pipe is available in lighter weights than other pipe making it possible to save money, not only on initial cost, but also in

transportation, handling and installation. By sizing the diameter of the pipe to the exact requirements, with exact lengths and factory-sized ends, the greatest economies can be realized.

Quotations are immediately available on inquiry.

Naylor Pipe Company
1270 East 92nd Street
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Telephone: 1-773-721-9400
Fax: 1-773-721-9494
Email: sales@naylorpipe.com
www.naylorpipe.com

Connecting infrastructure across the globe

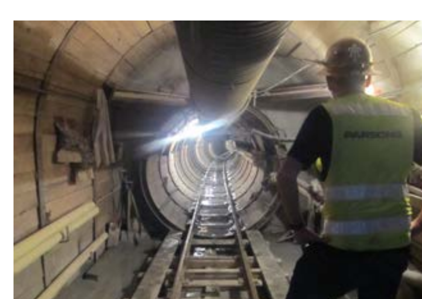
Photo credit: Byron I. Lim

Founded in 1944, Parsons is the premier source for end-to-end design-build transportation engineering capabilities, including expert multidisciplinary planning, all phases of construction and implementation, and maintenance and improvements. The firm employs more than 13,000 professionals around the world who are prepared to meet every technical and management challenge, no matter when or where, and to persevere until the job is done.

Parsons' Tunnel Division has contributed to 250 international tunnel projects, including the Caldecott Tunnel improvement project, which involves the construction of a fourth bore through the Berkeley Hills, near Oakland, California, and the Washington, D.C., Metro twin-tunnel program, cited by the American Underground Association as one of the most significant tunneling projects in the last 10 years.

Serving the underground engineering and program management needs of a diverse clientele, Parsons lends its expertise to projects such as underground utilities, water storage and transportation tunnels, and underground buildings. The firm has provided advisory services, performed subway construction, and delivered major highway tunnel projects, including the New York Gowanus Expressway and the English Channel Tunnel. Parsons offers a host of innovative tunneling techniques, like the New Austrian Tunneling Method, top-down tunneling, advanced hard-rock and soft-ground tunnel-boring machine technology, single-pass tunnel construction, and advanced tunnel waterproofing systems, to minimize the risks associated with underground structures. Throughout the firm's history, Parsons has worked to provide safer, better, more sustainable ways to travel the world — one project at a time. Learn more at www.parsons.com.

Parsons
www.parsons.com



A Successful Project Takes All Sizes

Small Brokk Played Huge Role in POMT Cross Passage Work

New underground routes connecting Watson Island and Dodge Island beneath Biscayne Bay near Miami wouldn't have been possible without some key players, both big and small.

A huge tunnel boring machine (TBM) was the star of the Port of Miami Tunnel (POMT) project, but a strong contender for best supporting equipment was a relatively tiny machine: the Brokk 400.

The Brokk 400, equipped with a hydraulic breaker, knocked out chunks of the concrete casing in one of the main traffic tunnels to begin one of the five cross passages in the POMT project.

While the Brokk 400 is only 14 feet long, 5 feet wide and less than 6 feet tall, it packs a powerful punch. The size-power combination was a big reason design-build contractor Bouygues Civil Works Florida used one to create cross passages between the project's twin 4,200-foot traffic tunnels, which are set to open in May 2014.

A close-up view of the beam manipulator designed specifically for the POMT project by Brokk's sister company, Kinshofer. Crews used the remote-controlled Brokk 400 and this beam manipulator to pick up and maneuver the steel support ribs into place in each cross passage.

Inside the passages, the machine delivered tremendous force with a hydraulic breaker to excavate hard soil, some of which was artificially reinforced with grout or through a freezing process to add stability. The next step was to place support ribs at 3½-foot intervals. The machine grasped the top section of each steel rib with a beam manipulator retooled specifically for the job, carried it to the installation point, lifted and positioned it, then held it in place while miners bolted on the lower sections.

Throughout the process, the Brokk machine enhanced safety for the miners. The remote control kept the operator away from potential cave-ins, and the electric drive ensured crewmembers weren't exposed to dangerous emissions.

All in all, the relatively small player gave a winning performance that delivered big results.

Brokk, Inc.
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Monroe, WA 98272 USA
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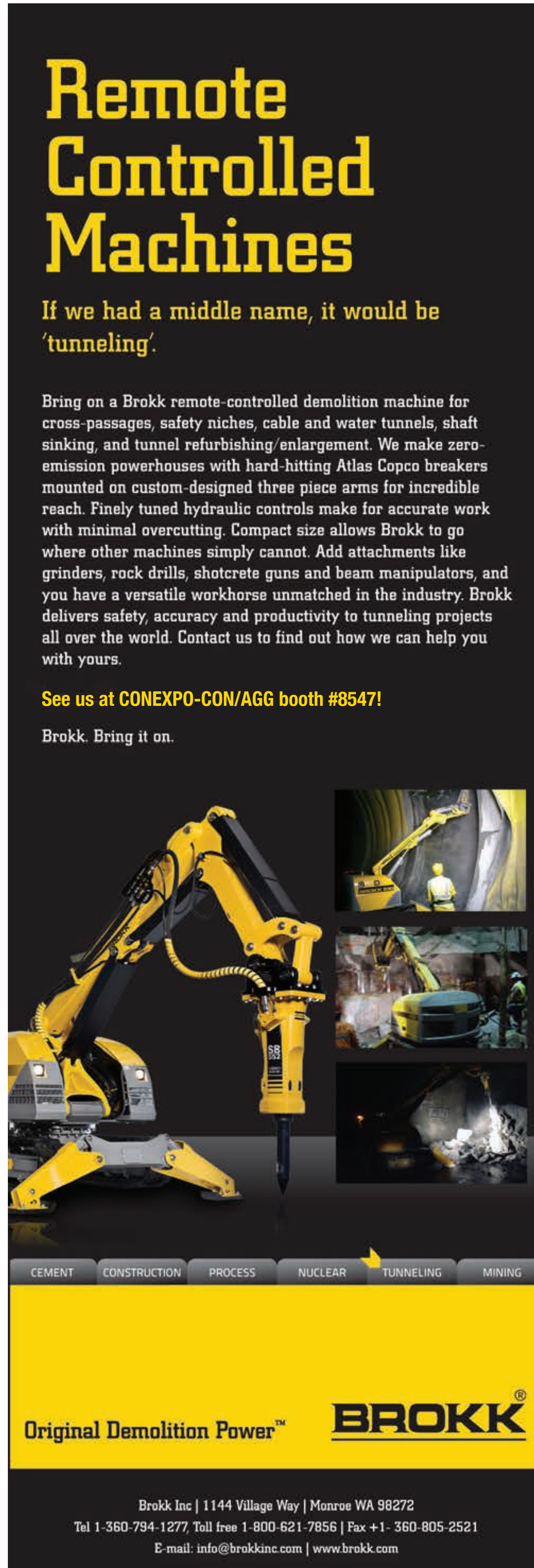
www.brokk.com



Tensar International Corporation

Tensar International Corporation (Tensar) offers a number of solutions to support the unique requirements of mining and tunneling construction. Tensar® Mining Systems include a family of polymeric grid products.

Made from high-strength, corrosion-resistant polymers, these geosynthetic reinforcement products are lightweight and easy to handle; this allows for safe, quick and easy installation, resulting in significantly fewer back, hand and facial injuries. Compared with metal reinforcement products, Tensar mining products can reduce installation and material handling time up to 75%.

Our Mining Systems offer cost-effective solutions for a wide range of underground mine and tunnel applications, including:

- Rib Control (Tensar® TriAx® and BX Mining Grid)
- Roof Control (Tensar® TriAx® and Tensar® UX3340 Roof Mats)
- Longwall Screens (Minex™ Rock Mesh)
- Highwall Screens (Tensar® TriAx® Mining Grid)
- Road Reinforcement (Spectra® Roadway Improvement System)

Tensar International Corporation
Telephone: +1-888-826-0715
www.tensarcorp.com

Rapid Set® Cement Products for Tunneling and Mining

CTS Cement Manufacturing Corporation is the largest manufacturer of Rapid Set® fast-setting hydraulic cement, well known for its versatility and high performance. Rapid Set® products are used for underground roadway repair, shotcrete, grout, cribbing for long- wall mining- mostly coal mining, and the precast concrete tunnel segment industry. Rapid Set® cement is not only a more durable alternative to portland cement on many projects, but its rapid-setting properties also make it an ideal solution for today's schedule- and budget-driven projects.

Rapid Set® cement offers reduced shrinkage and superior resistance to chemical attack. It achieves strength much faster and many installations can be put into service in as little time as one hour. Rapid Set® cement reaches typical compressive strengths in a few hours that an equivalent portland cement mix would require one month to achieve. In fact, Rapid Set® cement is a high performance binder that outperforms portland cement-based products consistently. Durability, versatility, speed and ease-of-use along with cost benefits are just some of the many benefits Rapid Set® cement offers.

Headquartered in Cypress, California, CTS manufactures Rapid Set® in the United States. Rapid Set® is distributed through a network of distributors and dealers throughout the United States and Canada. To learn more about Rapid Set® cement, visit www.ctscement.com or call 800-929-3030.

CTS Cement Manufacturing Corp.
Telephone: +1-800-929-3030
www.ctscement.com

Rapid Set®
Construction Cement Products

Antraquip Corporation

Antraquip Corp. has established itself as a leading designer, manufacturer and supplier of roadheaders, hydraulic rock grinders (roadheader attachments), shaft sinkers, specialty tracked machines with a variety of boom options, and tunnel support systems. The newest addition to the Antraquip product line are diamond tipped rock saw attachments for excavators designed to cut hard rock and reinforced concrete for specialty applications. Antraquip machines, built to the highest technical standards, are being used all over the world in a variety of civil engineering and mining projects.

Antraquip offers not only standard roadheaders in the 12 to 75 ton weight classes but is proud to offer project oriented engineering solutions. Some of the recent projects have included AQM roadheaders equipped with customized drilling attachments and fully automated remote control operation. Antraquip also provides various tunnel support products including lattice girders, steel sets, and arch canopy systems which they have supplied to some of the highest profile projects in North America in recent years.

In addition to offering project consultations, innovative rock cutting solutions and tunnel support systems, Antraquip recognizes the importance of after sales service. Their commitment to offering the best service and technical support is carried out by highly proficient and experienced service technicians and reinforced with the largest roadheader parts inventory in North America. Innovation, reliablility and experience offered by Antraquip, continues to make them your reliable partner for any tunnel or mining project.

Antraquip Corporation
Telephone: +1-301-665-1165
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www.antraquip.net

David R. Klug & Associates, Inc.

David R. Klug & Associates, Inc. provides international and national manufacturer representative services to the underground heavy civil and mine construction industries. The company specializes in the coordination of products, equipment and services for NATM, soft ground, precast segmental and conventional tunnel construction. This is inclusive of initial support systems, FRP bolts and soft-eye structures, high performance ultrafine cements, flexible membrane waterproofing systems, final lining reinforcement products, steel moulds, connectors and gasket sealing systems for one pass precast tunnel linings, tunnel profiling / scanning equipment and associated site services, design and supply of project specific material handling systems, and complex final lining forming systems.

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Telephone: +1-724-942-4670
FAX: +1-724-942-4671
Email: dklug@drklug.com

Bradshaw Offers Innovative Tunnel Engineering and Construction Technology

Bradshaw Construction Corporation strives to apply the most appropriate tunneling technology to each project based on its purpose, subsurface conditions and surface restrictions. The company's management team is proud of its ability to construct any type of tunnel in any soil condition both above and below the water table. From small hand mined, wood-box and liner plate tunnels to large NATM shotcrete-lined tunnels; from small pilot tube guided auger bores to large rib-and-board shield and tunnel boring machine (TBM) tunnels; from conventional pipe jacking to slurry microtunneling (MTBM) to earth pressure balance (EPB) TBM tunnels; and from hand mined drill and blast to rock tunnel boring machines (TBMs), Bradshaw Construction has a solution.

For your next project, let our knowledgeable staff of tunnel engineers and construction professionals create the most cost effective, safest, and highest quality solution for your unique tunneling needs.

Bradshaw Construction Corporation
175 West Liberty Road
Eldersburg, MD 21784 USA
Telephone: +1-410-970-8300
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www.bradshawcc.com

BROOKVILLE Exhibiting at NAT Conference in June

Brookville Equipment Corporation will present its line of customizable haulage and transportation equipment to the tunneling industry from June 23-25 in booth 528 at the North American Tunneling (NAT) Conference, to be held at the J.W. Marriott in Los Angeles. Brookville representatives will highlight the 96-year-old company's latest product innovations and enhancements for its line of locomotives, personnel carriers and combination vehicles.

Brookville manufactures customized battery and diesel powered equipment for the mining and tunneling industries and has supplied custom equipment to some of the industry's most notable tunneling projects, including the Traylor Brothers East Side Access Project in New York City and the Stillwater Mine in Montana. In 2014, Brookville is slated to deliver three permissible 27-ton diesel locomotives to the Walsh-Shea Corridor Constructors' Crenshaw/LAX Transit Corridor Tunnel Project.

For more on BROOKVILLE's customized tunneling equipment, visit www.brookvillecorp.com

Brookville Equipment Corp.
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Telephone: +1-814-849-2000
www.brookvillecorp.com

ABC Industries, Inc.

The most extreme tunneling and underground construction sites demand the most dependable, durable ventilation equipment available today. Since 1926, ABC Industries, Inc. has been a leading provider of high quality, customized ducting solutions to many of the largest mine and tunnel operations in North America and around the world. ABC's complete line of MineVent® and TruOval MineVent® layflat blower tubing, MineDuct® wire-reinforced exhaust ducting, RigiDuct® filament-wound fiberglass ducting, brattice, fly pads, blast curtains, fans, and accessories offer underground professionals a complete solution for ventilation products. As tunneling and underground construction continue to evolve, ABC proactively collaborates with industry professionals to engineer unique, high quality ventilation products to exceed the industry's needs tomorrow and beyond.

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Email: sales@abc-industries.net
www.abc-industries.net

McDowell Brothers Industries, Inc.

McDowell has been a leader since 1968 in providing the Underground Mining sector with their new and used heavy equipment requirements.

With more than 100 employees, 5 shops, close to 75,000 sq. ft. of working space, McDowell is now synonymous with mining and to prove it, it maintains the largest stock of used, rebuilt and new equipment. Clients can access rebuilt, reconditioned or "as is" equipment for an outright purchase or rental.

A new exchange parts program offers clients the flexibility of exchanging core parts for rebuilt ones immediately, thus saving down time or inventory expenses.

Auditing, commissioning and consignment are also offered by McDowell for clients' surplus equipment. Our search to acquire additional late model equipment is ongoing.

McDowell Brothers Industries, Inc.
Telephone: +1-705-566-8190
Email: sales@bmcdowell.com
www.bmcdowell.com

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Euclid Chemical

Euclid Chemical serves the tunneling industry with new and innovative products developed for annulus grouting, soil conditioning and precast segments. Euclid Chemical has been involved several large tunnel projects throughout the Americas and continues to be the innovative leader in this market segment. Euclid Chemical staff has been influential in the design of successful annulus grout mixes for several tunnel projects. For any underground concrete application, The Euclid Chemical Company offers superior products and customer service to the tunneling industry.

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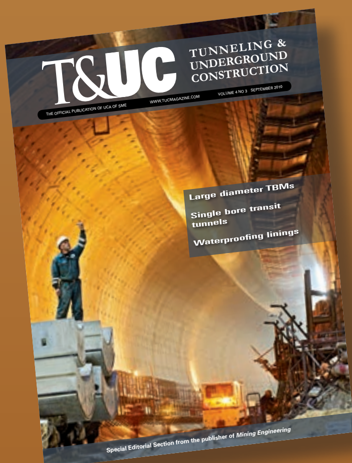

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SURECRETE INC.

155 NE 100th Street, Suite 300 • Seattle, WA 98125
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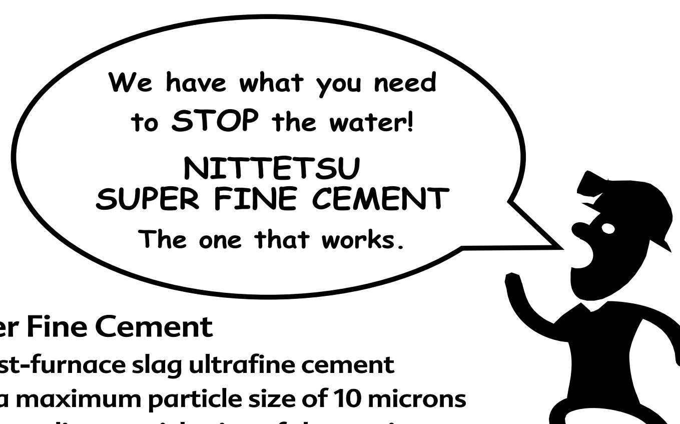
info@surecrete.com • www.surecrete.com

Surecrete Inc. specializes in furnishing bagged cementitious materials, mixing and placing equipment, and related accessories to the heavy civil tunnel, geotechnical and mining markets. Our product lines include Nittetsu Super Fine ultrafine cement, rheology modifiers, specialty admixtures, and a complete selection of packaged wet and dry shotcrete, concrete and grout mixes. We also represent several major equipment manufacturers specializing in the mixing and placing of shotcrete, concrete and grouts. For more information, visit our web site at www.surecrete.com


Concrete materials for Chester Creek Dam, Metlakatla, AK



Super Fine Cement

A blast-furnace slag ultrafine cement with a maximum particle size of 10 microns and a median particle size of three microns.

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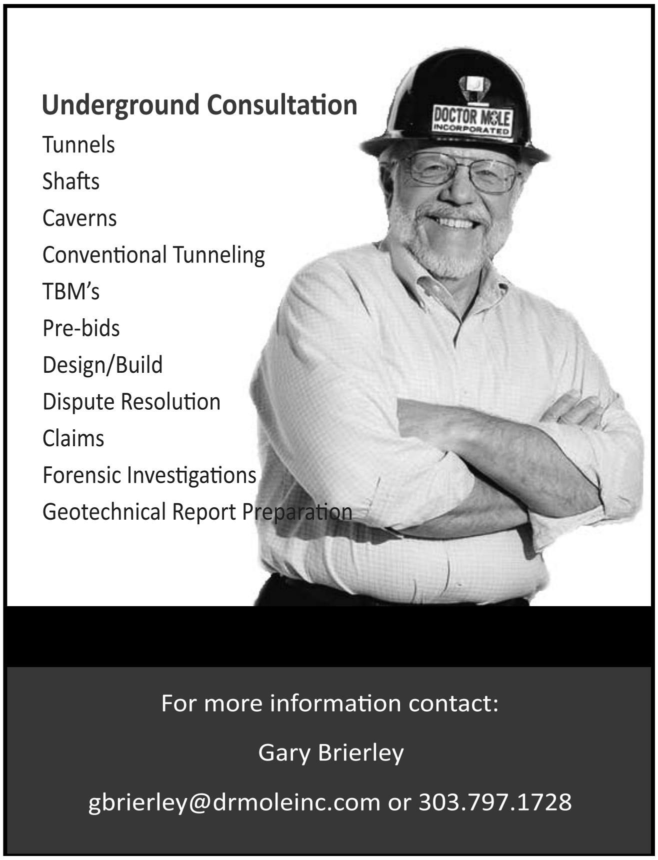

Announcing Doctor Mole Incorporated

Dr. Gary S. Brierley started operating as an independent consultant under the corporate name of Doctor Mole Incorporated (DMI) on January 1, 2013. Doctor Mole Incorporated is a one-stop-shopping-center for the design of all types of underground openings in all types of ground conditions. DMI can help clients meet their underground design and construction needs. No job is too small and it is our intention to help owners, designers, contractors, geotechnical engineers, and developers create successful underground projects from start to finish. Based in Denver, Colorado, DMI is strategically located and available to help with projects across the United States. Give us a call at 303.797.1728 or visit us on the web at www.drmoleinc.com.

Doctor Mole Incorporated
990 S. Broadway, Suite 222
Denver, CO 80209 USA
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DOCTOR MOLE INCORPORATED

40 Years of High-Performance Waterproofing Solutions

Established in 1970, Stirling Lloyd leads the world in the provision of high performance waterproofing systems for tunnels and bridges. Utilizing our advanced MMA technology, over 75 million square feet of Integritank and Eliminator sprayed membranes have been applied and are protecting many of the world's key infrastructure crossings from premature degradation.

Innovative solutions are available for the external waterproofing of cut and cover and immersed tube tunnels as well as for the waterproofing of suspended decks in all tunnel types. The latest addition to the Company's range is the Integritank HF sprayed waterproofing membrane, which enables owners, designers and contractors to effectively waterproof the internal linings of SCL/NATM tunnels, and can be non-destructively tested to confirm 100% integrity.

Stirling Lloyd Products, Inc.
152 Rockwell Road, Building A
Newington, CT 06111 USA
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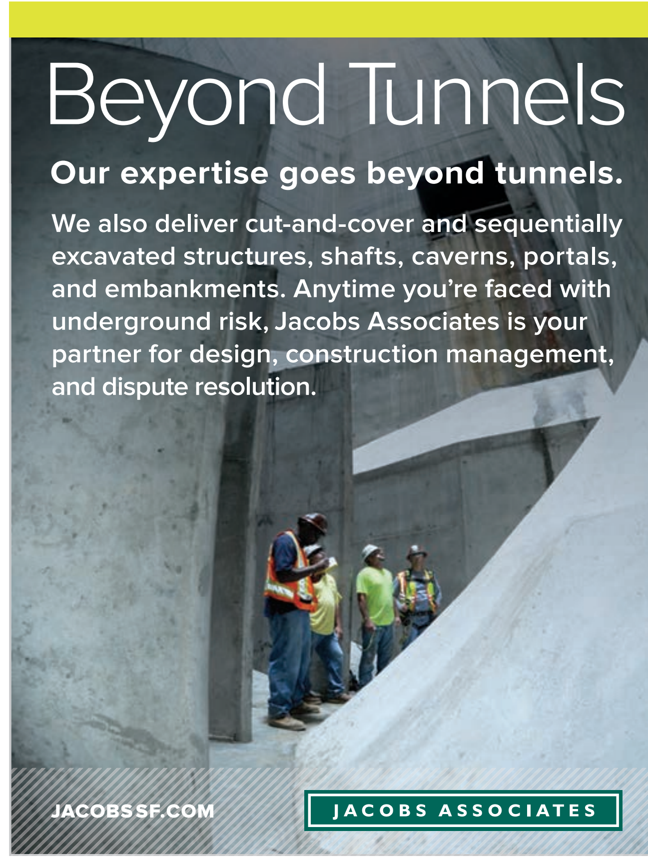
Fax: +1-860-666-5016
Email: northamerica@stirlinglloyd.com
www.stirlinglloyd.com

Final Design Commences on LA's New Outfall Tunnel

Jacobs Associates, along with teaming partner Parsons, is currently developing the final design for the Sanitation Districts of Los Angeles County's 18-foot-diameter, 7-mile-long Effluent Outfall Tunnel. Treated effluent will be conveyed through the tunnel to a manifold structure and thereafter discharged through four existing ocean outfalls. Apart from providing additional capacity, the new tunnel will allow the two existing tunnels, which have been in operation since their construction in 1937 and 1958, to be taken off-line, inspected, and repaired if needed. Significant challenges to design and construction include fault crossings, a relatively high net internal operating pressure, the presence of natural hydrocarbons, and the potential for gassy ground. Final design is anticipated to be completed by late 2015, with a target procurement date in early 2016.

Jacobs Associates
Telephone: +1-800-842-3794
www.jacobssf.com



Dā-mite Rock Splitting Mortar from the Daigh Company, Inc.

Daigh Co. is the supplier of Dā-mite Rock Splitting Mortar. Dā-mite is used to fracture rock and concrete in "no-blast" conditions. Dā-mite is an ideal and effective tool for fracturing mass rock, boulders, trench rock, dimensional stone, concrete and reinforced concrete. "Dā-mite is mixed with water and placed in the appropriately placed predrilled holes, where it sets and expands, fracturing the rock/concrete". No license required. There are four grades of Dā-mite, providing enough versatility to be utilized in drilled hole diameters from 1 in. to 2 ¾ in.

Daigh Company, Inc.
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Cumming, GA 30040
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Fax: +1-770-887-3783
Email: sales@daighcompany.com
www.daighcompany.com

Dā-mite®
Rock Splitting Mortar

Custom Equipment Design Specialists

Kelley Engineered Equipment, LLC was founded in 2007 by Brian and Cindy Kelley. The firm is located in Gretna, Nebraska and has a growing staff of mechanical engineers, control system engineers, designers and drafters with extensive experience in tunneling and mining equipment design. Brian has 25 years of tunneling equipment design experience at Robbins, Kiewit and Kelley Engineered Equipment. Mechanical Engineering PE licenses are held in Nebraska, New York, California, Texas, and Washington State. The company specializes in custom tunneling equipment design, including lifting systems, mucking systems, gantries, pipe carriers, trailing gear, custom attachments, conveyors, lift cars, equipment modifications, ventilation personnel access systems and more. Kelley Engineered Equipment has a growing line of standard products including mobile reelers for wire rope and conveyor belt, hydraulic drive pulleys and material handling/storage bins and more.

Kelley Engineered Equipment, LLC
11281 S. 232nd Street
Gretna, NE 68028 USA
Telephone: +1-402-267-0143
www.keellc.com

Brierley Associates

Twin Box Tunnels, Liberty University, Lynchburg, VA

Brierley Associates is a privately-held tunnel, trenchless, geotechnical, and geo-structural design firm with offices strategically located in nine states. With over 55 underground engineers and geologists, Brierley Associates has a long history of delivering recognizable value to their clients by providing cost effective and constructible solutions for underground projects.

The nationwide and international underground project knowledgebase of Brierley Associates is key to anticipating ground behavior and helping our clients with design and construction of successful projects which is a cornerstone of Brierley's business vision to *"Create Space Underground."*

Brierley News: Designated tunnel engineer by Southland Contracting for Kaneohe-Kailua Sewer Tunnel project, Hawaii; Selected for CM team I-70 Twin Tunnel Westbound enlargement, Colorado; Successfully completed Twin Box Tunnels at Liberty University, Virginia.

Brierley Associates
www.brierleyassociates.com

HIC Fibers is selling direct in North and South America

HIC Fibers, Inc. has opened offices in Los Angeles, California for North America and Lima, Peru for Central and South America.

This marks the first time that HIC Corp. based in Korea, has opened offices with the intention of selling direct to the end user in lieu of selling strictly through distributors.

HIC Fibers has the exclusive technology and rich know-how in manufacturing of steel fibers. HIC Fibers can provide you a steel fiber of your choice in length, diameter and package.

Contact HIC Fibers direct at (323)-935-4500 or visit us on the web at HIC Fibers.com

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4801 Wilshire Blvd., Ste. 305
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FEATURE ARTICLE

Waneta expansion project: Penstock tunnels

The Waneta Expansion Project in Trail, British Columbia included the construction of two penstock tunnels.

The Waneta Expansion Project (WAX) is located near the existing Waneta Dam site at the confluence of the Pend d'Oreille and Columbia rivers, approximately 10 km (6.2 miles) south of Trail, BC, Canada. The WAX owners consist of a partnership between Fortis Inc., Columbia Basin Trust and the Columbia Power Corp. This design-build project was awarded to SNC-Lavalin in late 2010 and is expected to be operational in mid-2015.

Ben Roberds and Eric Gemin

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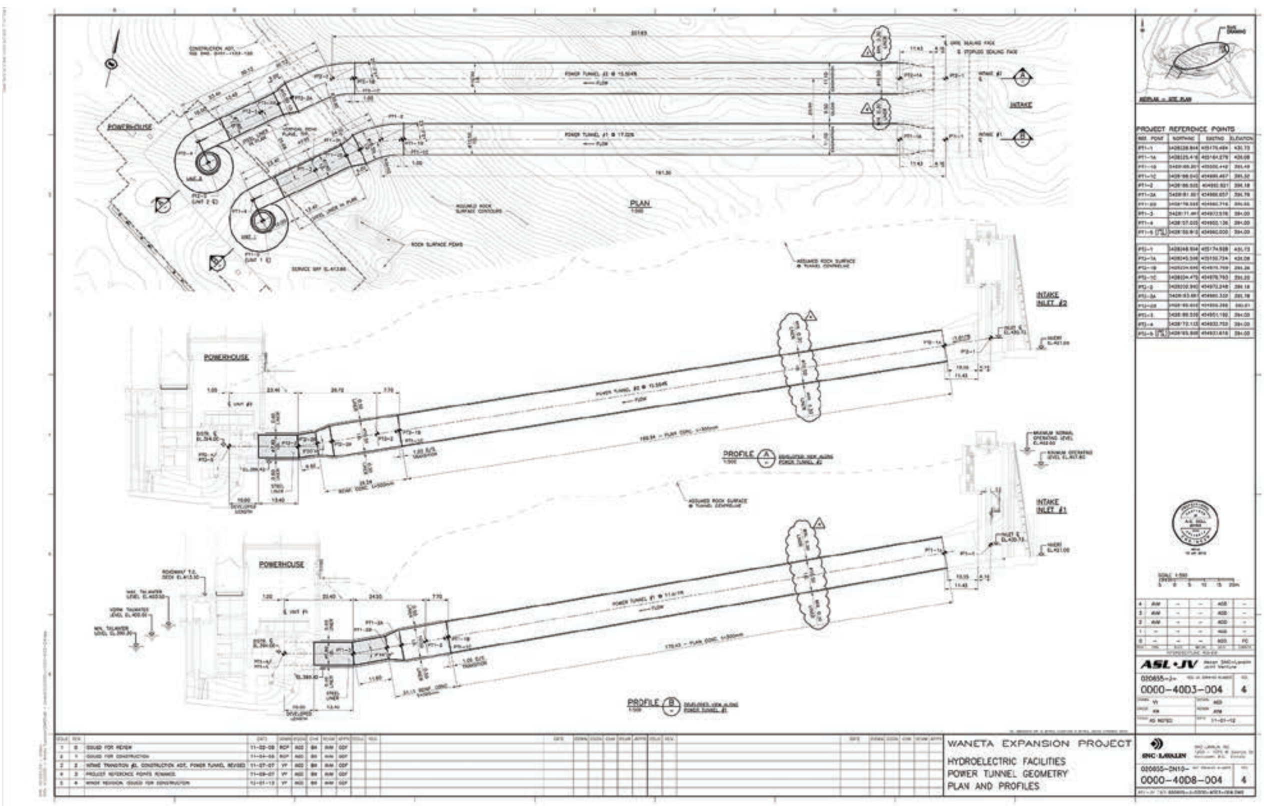
The WAX consists of a new 335-MW powerhouse, including two new Francis turbine units, each generating approximately 167 MW. The powerhouse is located downstream of the existing Waneta Dam, and will make use of excess water that would otherwise be spilled during the runoff season. Water will be funneled to the turbines through an intake structure and two 10.5-m (34.5-ft) diameter, concrete-lined Penstock Tunnels. A 10-km (6.2-mile) transmission line will connect the powerhouse to existing electrical grids.

Redpath/FKCI Waneta Tunnelers (RFK) was subcontracted by the heavy civil contractor, the Aecon/SNC Lavalin (ASL) joint venture, to excavate the two penstock tunnels and install the cast-in-place concrete liner. RFK is a joint venture partnership between J.S. Redpath Ltd., an underground mine contractor located in North Bay, Ontario, and Frontier-Kemper Constructors ULC, a heavy civil tunneling contractor based in Nova Scotia, Canada. Since penstock tunnel excavation was planned using drill-and-blast methods with a significant grade of more than 17 percent, the combined experience of these two contractors was a perfect match.

FIG. 1

Tunnel plan and profile.



Site specific

With the project site being located along two major rivers, environmental awareness was, and remains, a major consideration to all work. Protected species such as the white sturgeon, rubber boa snake and yellow bellyied marmot reside in areas surrounding the project site. All site contractors were required to adhere to strict environmental regulations, especially those regarding the use of concrete, explosives and mobile equipment. An onsite water treatment facility was set up to treat all construction and runoff water that came in contact with the site prior to discharge.

The owner's requirements of zero fly rock and limited blast vibrations added to the excavation complexity. A single lane highway bridge and an existing railroad bridge, constructed during the 1940s, were located approximately 300 m (985 ft) from the project site and were monitored during every blast. Blast vibrations were also an important consideration since powerhouse, intake and tunnel excavations all took place within 500 m (1,640 ft) of the existing Waneta Dam. All blasting was closely monitored to ensure there were no adverse effects to the dam, railroad and highway bridges. Blast vibrations were kept below 50 mm (2 in.) per second peak particle velocity.

Access adit

In order to start the Penstock Tunnel excavation early, while the powerhouse and intake excavations were underway, a smaller access adit tunnel was developed. The access adit was 6-m- (19-ft-) wide and 6-m- (19-ft-) tall, modified horseshoe in shape, and 135-m- (443-ft-) long, with a downhill grade of 12 percent. Developing the access adit allowed RFK to excavate the Penstock Tunnels and remain off of the surface works critical path and out of the way of other site excavations. The access adit was also used for initial training for those workers not familiar with underground excavations.

Round lengths of 4 m (13 ft) were drilled using a two-boom Tamrock drill jumbo. A typical round consisted of 75 holes, 45 mm (1.7 in.) in diameter with three 100-mm (4-in.) diameter relief holes in the cut. Hole spacing was approximately 800 mm x 800 mm (31 in. x 31 in.). Explosives used were packaged emulsion, "stick powder," with Nonel detonators. All blasts were initiated using electric blasting caps that were tied into a detonating cord. Ground support in the access adit consisted of a minimum 50-mm (2-in.) layer of 35-MPa, fiber-reinforced, shotcrete followed by a typical 2 m x 2 m (6.5 ft x 6.5 ft) pattern of 2.4-m- (7.8-ft-) long expandable (Swellex) type rock bolts. The access adit had a low cover and would be used as primary ingress/egress during the tunnel excavation and the concrete liner phase. Eight steel arch sets were, therefore, installed at the portal on 1-m (3-ft) centers to provide additional ground support. All utilities and ventilation were routed through the steel sets and down the access adit. RFK was able to complete the 135-m- (443-ft-) long access adit in 40 days, working five days per week with two 10-hour shifts per day (Fig. 2.).

FIG. 2

Portal and access adit development.

Penstock tunnel excavation

Two penstock tunnels were designed parallel, 10 m (32 ft) apart, horseshoe in shape and approximately 11 m (36 ft) in diameter. After excavation, a 300-mm- (11-in.-) thick, cast-in-place concrete liner would be installed for hydraulic efficiency purposes only. Due to the large diameter of the penstock tunnels, RFK determined the safest and most efficient excavation method would be top heading and bottom bench. Separating the excavation into top and bottom halves allowed RFK to keep tight control over ground support and minimize the amount of open ground at any time. Another deciding factor was the availability of smaller mobile equipment.

Based on the tunnel size and expected ground conditions, initial planning suggested further dividing the excavation through the use of a split top heading method. In this scenario, the top heading in each penstock tunnel would have two separate working faces side by side, one slightly ahead of the other, each approximately 5-m- (16-ft-) wide x 5-m- (16-ft-) tall. This method, similar to a pilot and slash, would have provided four working faces at any given time, yielding greater flexibility in the excavation cycle.

Conversely, sequencing the excavation cycles between the four working faces would have required careful day-to-day planning and left little room for error such as equipment breakdowns. Bottom bench excavation was always planned as full face using horizontal drilling and taken after top heading excavations were completed in each tunnel.

As access adit excavation neared the intersection of the penstock tunnels, RFK encountered better than expected ground conditions and determined that a full width top heading could be taken without compromising safety during the ground support cycle. Based on this information, RFK chose to take a full face top heading, 11-m- (36-ft-) wide by 5-m- (16-ft-) tall, semicircular in shape. Doing so eliminated the flexibility of four separate working faces but allowed RFK to advance the entire top heading with one blast instead of two, making the operation more efficient.

Controlled blasting techniques were employed during top heading excavations to help define the excavation line and minimize overbreak in efforts to reduce the amount of concrete placed during the tunnel lining phase. Top heading drill patterns had approximately 98 blast holes with interior spacing averaging 800 mm x 800 mm (31 in. x 31 in.). The perimeter of each round was line drilled with spacing averaging 450 mm (17 in.), and every other hole loaded during the blast, 4-m (12-ft) round lengths were drilled using the Tamrock two-boom jumbo. Mucking was done using two Cat Elphinstone R1700G load haul dump (LHD) scoops. Due to the wide top heading, 11 m (36 ft), RFK was able to use both LHDs to muck the face simultaneously, passing in the tunnel near the face. The use of two LHDs at once helped decrease the mucking cycle.

From the access adit intersection power tunnel, excavation was uphill at approximately 17 percent for 190 m (623 ft) and downhill at approximately 15 percent for 20 m (65 ft) in both tunnels. Blasted rock was taken to the downhill side of one power tunnel that was used as a muck bay. The downhill side of the adjacent tunnel was used as a sump. Blasted rock was hauled to surface from the muck bay after the heading was completely mucked out.

Initial temporary ground support, identical to that installed in the access adit, was installed in the penstock tunnels to allow RFK to continually advance the heading. All shotcrete was placed using a Normet Spraymec robotic shotcrete machine. Shotcrete was transported from surface using a single, 7-m^3 (247-cu ft), underground remix truck. Permanent ground support, consisting of 22-mm- (0.8-in.-) diameter x 4-m- (13-ft-) long, fully

FIG. 3

Top heading and bottom bench excavation.

grouted rebar dowels were installed noncritical path behind the working face. All permanent ground support was installed based on a prescription by the onsite geotechnical engineer. Five separate rock classifications were defined and evaluations carried out daily after each blast was taken. Ground support classifications ranged from Class I, spot dowels only, to Class V, 100 mm (4 in.) of fiber-reinforced shotcrete and lattice girders. Ground conditions in the penstock tunnels were good enough that RFK was only required to install Class I and Class II ground support.

To ventilate the underground excavations, RFK used a fully reversible suction system. Two 1.3-m- (4.2-ft-) diameter, 149-kW (200-hp) ventilation fans were located on the surface adjacent to the portal entrance. Two separate steel ducts of the same diameter were connected to the fans and advanced through the access adit. Once at the access adit/penstock tunnel intersection, one steel duct would split off to each tunnel. The steel ventilation duct always remained approximately 18 m (60 ft) away from the working face in the penstock tunnels, while a smaller 22-kW (30-hp), 0.9-m- (3-ft-) diameter booster fan was used to push fresh air directly toward the working face. The 22-kW (30-hp) booster fans were set up in each tunnel in a fixed location and used 0.9 m (1 ft) flexible ducting, advanced with the heading. Average air flows in the penstock tunnels were approximately 5,500 m^3 (176 cu ft) per minute. Other utilities such as compressed air and service water were carried in 100-mm- (4-in.-) diameter HDPE pipe hung along the walls of each tunnel. Electrical cables for tunnel lighting and equipment were carried on the opposite side of the tunnel as the compressed air and water lines.

RFK was able to excavate both top headings, 451 lineal meters total, in 139 days and completed the bottom benches in only 82 days.

Two disadvantages associated with the steep grade excavations were difficulty mucking uphill and increased exposure during ground support operations. RFK was able to mitigate the latter by using a remote shotcrete arm on the Normet Spraymec, allowing an initial layer of shotcrete to be installed prior to bolting. Shotcrete accelerator was used to reduce cure times so that bolts could be installed during the same shift. A mechanized bolting machine was used to install the expandable bolts, again minimizing exposure to the operators. Excavating and mucking uphill was technically more difficult for operators but the chosen equipment was designed for underground mines, where steep grades are more common. The slope was hard on tires but, with careful operation, standard equipment was used effectively without requiring modification.

One advantage of the steep grade was that a dewatering pump was not required during ground support, drilling and loading cycles to keep the face dry.

Concrete liner

A smooth concrete liner was specified to minimize head losses through the penstock tunnels. Initial plans were for a modified horseshoe, or D-shaped, tunnel cross section with finished inside dimensions of 10 m x 10 m (33 ft x 33 ft). Prior to the start of excavation, a change order was approved, converting the finished tunnel shape to full round 10.5 m (34.5 m) finished diameter. With permanent ground support being installed during the excavation phase, the liners would not be exposed to any ground loads. The maximum design load was, thus, the pressure differential caused by rapid dewatering. While the tunnels are in use, and full of water, the ground around them will become saturated with an equal hydrostatic pressure. In an emergency, the intake gates could be closed and water would drain out of the tunnels in approximately two minutes. In this case of rapid dewatering, the surrounding ground will maintain the full hydraulic head of up to 70 m (230 ft) on the concrete liner until the pressure slowly dissipates through leakage. With this in mind, the designers specified the use of 35-MPa plain concrete to cast the 300-mm- (11-in.-) thick liner.

It is notable that no reinforcing bar or fiber was required in the final concrete liner. The tunnel excavations were fully supported before concrete placement, and in the circular shape, plain concrete was able to meet the design requirements. Reinforcement could have been used to reduce shrinkage cracking of the liner, but minor cracking was actually preferred as it will allow drainage into the tunnel during a rapid dewatering condition. Construction joints similarly required no water stop or bonding agents that would hinder equalization of water pressures.

The design requirements did have restrictive finish specifications. The tunnel liner could not vary from line or grade by more than 12 mm (0.5 in.) or by dimension/shape by more than 0.5 percent. The 10.5-m- (34.5-ft-) diameter finished tunnel up to 52 mm (2 in.) of differential between the height and width were allowed. Liner finish quality had to meet the British Columbia Ministry of Transportation Class II requirements. This required all honeycombs more than 25-mm- (1-in.-) diameter be filled, all bug holes more than 5-mm- (0.2-in.-) diameter be pointed and the surface given a rubbed finish where more than 50 such voids occurred per square meter. Surface irregularities 3-mm- (0.1 in.-) high were allowed with restrictions on their size and number.

FIG. 4

Tunnel form inspection.

Tunnel form design and fabrication

In order to keep tunnel concrete works off the overall project's critical path, RFK requested proposals from seven suppliers for a self-advancing concrete form that would allow a full pour cycle every 24 hours, safely operate on a 17-percent slope, and be able to meet the specified finish requirements. Ceresola Tunnel Lining Systems (CTLS) of Switzerland (now Max Bögl Schweiz AG) was the chosen supplier and undertook the design and fabrication of a walking beam style steel form. It was agreed the form would be able to cast a 7.5-m- (24-ft-) long full round section of the liner, walk itself through the tunnel on its own carrier and be designed to operate on a 17-percent slope. The form used by RFK on this project was the largest full round form CTLS had constructed to date.

Since the tunnel form was only 7.5-m- (24-ft-) long, internal supports "spud pins" were not required. To prevent movement during concrete placement, the front of the form was braced against the surrounding rock and the rear against the previous concrete pour by six large screw jacks on each end, two screw jacks in the crown, one on each side, and two in the invert.

In an effort to reduce cycle times, a steel-framed, cantilever bulkhead system was developed that would fasten to the upstream leading edge of the steel formwork, eliminating the need to brace the bulkhead against the rock. In surface trials, the provided cantilever bulkhead system proved difficult to fit around other installations on the end of the form such as walkways and hydraulic cylinders. The individual parts were also too heavy to efficiently assemble by hand on a regular basis. RFK decided to use rough cut 2.8 bulkhead material and support it using traditional wood 2.4 walers and stiff-backs. The wood supports were not designed to withstand concrete loads in cantilever so they were pinned and braced to the perimeter rock using 20-mm (0.7-in.) steel dowels.

Advancement was accomplished by designing the round form and the carrier to walk itself. Rollers were installed on the carrier beams to allow the form to slide back and forth with the carrier resting on the ground. The same rollers could be used to move the carrier when supported by the form. Not having wheels on the ground meant the form could be walked over mildly uneven surfaces, did not require a rail system and was stable in the sloped tunnel. The form could also be shifted sideways by means of small cylinders in the feet of the carrier.

The tunnel form was fabricated and structural elements assembled for testing and inspection in Seveso, Italy. After workshop inspection, the form was disassembled and loaded into 11 standard 12-m (40-ft) shipping containers for transport to Trail, BC. On arrival, the 15 full form elements (1.5 m x 7.5 m x 1.6 m or 5 ft x 24 ft x 5.2 ft) up to 4,200 kg (4.2 st) each), 10 half elements for the invert, handrails and miscellaneous parts were skidded out of the shipping containers at a storage yard approximately 7 km (4.3 mile) from the project site. Each element was then individually transported to the assembly location at the project site as needed (Fig 4.)

Tunnel form assembly

On site, the assembly location was on the surface near the head pond and adjacent to the 40-m- (131-ft-) deep intake excavation. The carrier itself was assembled, then five elements comprising the crown were bolted

FIG. 5

Tunnel form reassembly in bottom of intake excavation.

together. The crown was lifted as one unit and attached to the carrier. The side elements, or wings, were bolted together and hung from the crown while the invert was assembled in place under the carrier. After the major elements were bolted together, the electrical, hydraulic, pneumatic, communications and water systems were installed. Overall, surface assembly took 11 weeks. Once assembled, the form was tested and modifications were made as needed before walking the form under its own power to the edge of the intake excavation.

A location for the shortest lift crane radius (15 m or 49 ft) into the intake was cleared and leveled for placement of a 249-t (275-st) lattice boom crawler crane. This gave a load limit of 48,000 kg (48 st) at the self-imposed 75 percent capacity to avoid the restrictions of a critical lift. Fully assembled, the form weighed approximately 22,000 kg (135 st).

The form elements, concrete placer car and feet were removed to allow the carrier to be lifted and set in the bottom of the intake excavation. The invert, carrier, crown and sides, each containing all installed utilities and subassemblies, were then hoisted to the bottom of the intake, in order. Each part was directly attached to the elements already in place, reattaching the invert last.

After full reassembly, the form was shifted 20 m (65 ft) sideways using 200-mm (8-in.) side adjustment cylinders and aligned with Tunnel 2. The form was then walked, as intended, to the downstream starting station of Tunnel 2 over the course of approximately one week. Although designed for the slope, a large moment was inflicted on the system as it was walked down the tunnel. When the carrier was raised and extended forward down the tunnel, two screw jack feet on the lower end supported the majority of the system's weight — along with a moment from the extended carrier. An anchor pin assembly was provided on the upper end of the form to arrest longitudinal forces, but it was difficult to prevent load transfer to the vertical supports. Extreme care was required while walking downhill to prevent damage to the screw jacks. Advancing the form back up the tunnel did not have the same challenges. The carrier was advanced and set in place while the form was still enclosed in the previous pour's concrete. The tight encasement prevented any movement, with loads being distributed into the concrete.

Adjustments had to be made after the first two pours to account for the rear of the form and carrier advancing into the poured liner. After the third pour, a cycle was defined, although not close to the 24-hour target. A cycle consisted of fixing the form in place, building the bulkhead, pouring concrete, curing the concrete, striping the bulkhead, advancing the carrier, advancing the form, cleaning, oiling and aligning the form for the next pour. After 10 pours, the overall cycle was typically 48 hours (four shifts). Of the 48-hour cycle, concrete placement took only seven hours. The following shift stripped the bulkhead and moved the carrier forward. On the second day, the form was advanced and reset. Night shift then started a new bulkhead and set up for the next pour. By the 15th pour, the cycle had been reduced to 36 hours.

Several concrete mixes were submitted for approval to allow flexibility based on weather conditions and temperatures. Because placement happened during the spring and summer months, a mix design with the highest water/cement ratio (0.42) and highest fly ash content (22 percent) was used. RFK determined this mix could be accelerated as needed to keep up with the pour schedule. Tight controls were necessary to ensure the concrete would perform as designed. Stripping strength of 4 MPa had to be reachable within 12 hours. Accelerator (typically 181mL/100 kg cementitious) was added on site no more than 30 minutes prior to start of discharge. A minimum 180-mm (7-in.) slump was needed because of the limited access behind the form to place and vibrate. At 220-mm (8.6-in.) slump, the concrete mix was too wet and began to segregate. The steep grade and use of high slump concrete helped to ensure all surface irregularities from the blasted rock were filled.

A maturity meter was used to monitor temperature production and rate of hydration of the placed concrete to allow stripping as soon as the concrete reached strength. Trial batches defined the rate of compressive strength gain to the time temperature factor (TTF) output of the meter. When the TTF read 350, the bulkhead could be safely stripped (2 MPa). As soon as it read 450 (4 MPa), the concrete was self-supporting and the steel form could be advanced.

FIG. 6

Finished concrete liner.

Results

Design of the tunnel form was based on the goal of placing one section of the tunnel liner every 24 hours on a schedule of three shifts/day, eight hours/shift. Actual durations resulted in an average of one placement every two days on the first tunnel (25 pours in 49 work days) and one placement every 1.5 days (23 pours in 37 work days) in the second tunnel. Actual production was based on two shifts working 7 am to 5 pm and 6 pm to 4 am. Timing of the shifts allowed for a hot change from day to evening shift when required, but hot changes were not possible from evening to day shift. Pours that could not be started by the beginning of the night shift were pushed back to the start of the next day shift.

Throughout both tunnels, the pumping time averaged a stable seven hours, the variables of the cycle were the time spent curing, breaking down, moving forward and resetting the form. After initial startup, kinks were worked out. The first tunnel typically required a minimum of two full shifts to move and set up the form. If a pour started on Monday morning, the form could be set up to pour again Tuesday evening. Difficulties in securing concrete for evening pours, necessary conservative scheduling of start times, shift limitations and the learning curve extended the average cycle to a full two days. In the second tunnel, experience led to faster cycle times and tighter scheduling, allowing pours as often as every 26 hours. Shift and material availability limitations, as well as the continued learning curve, pushed the average cycle to 36 hours.

An unexpected challenge of the concrete liner was excessive bug hole formation, which required extra work to meet the finish requirement. In common concrete work, a flat slab is placed with no upper form, allowing entrapped air bubbles to escape into free air at the surface. A troweled finish would meet the finish specification with little or no followup work. Vertical walls are vibrated in place, allowing air bubbles to escape out the top of the pour, typically leaving only a small number of bug holes in the vertical surface, depending on the concrete mix and placement practices. The exposed face of a vertical wall should require limited effort to fill bug holes and patch rock pockets in order to meet a Class II finish.

The concrete placed below spring line in this project was cast against the broad surface of the form. The shallow curve of the large radius did not allow air bubbles to slide along the steel and escape into free air. The number of bug holes experienced required a rubbed finish to be installed below spring line in the whole of both tunnels. A stiff sand and cement grout was troweled over the concrete, allowed to take initial set and "rubbed" to create a uniform flat surface. The number of manhours spent finishing the concrete were comparable to the number spent placing it.

Efforts to improve the finished concrete surface included monitoring and fine tuning placement procedures, testing various form release agents and minor adjustments to the mix design. Variables associated with placement include injection ports, which ones and how often they are switched; and vibrator use sequence and duration. Several form release agents were tested to see if a water-based product could be found to further reduce bug holes. Oil based form release agents were not used as any residue would create a slip hazard on the tunnel slope. Adjustments to the concrete mix design primarily included minor changes to the slump, entrained air content and various workability admixtures of the concrete. The fine tuning efforts had little effect on the rate of bug hole formation but did result in more efficient placing procedures and consistent concrete mix. The finish was also more consistent, though it still did not meet the finish requirements.

Regardless of the highlighted struggles, the methodology and use of the full round form proved to be an effective choice for this project. The challenging slope was managed and a round concrete surface meeting the structural, shape and alignment requirements was produced. Very little remedial finish work beyond the patching of bug holes was required in any area. ■

FEATURE ARTICLE

Subsurface public-private partnership projects: Brave new world for risk allocation

The Port of Miami project is one of many public-private partnership projects in which a range of risk allocation approaches to subsurface conditions have been adopted.

Public-private partnerships (PPP) are gaining in popularity at the federal, state and local levels as the public sector seeks private capital to finance infrastructure and other projects that traditionally have been funded with public funds. In general, a PPP involves a development agreement between a public owner and a private sector concessionaire. Under the development agreement, the concessionaire is responsible for financing, designing, constructing and typically operating and maintaining the completed project for a concession period (often multi-decades in duration). The concessionaire typically enters into an agreement — the design-build agreement — with a design-builder to design and construct the project. The concessionaire may secure financing from banks, investors or from a combination of these and other sources (collectively the financier). While the PPP experience in the United States has been modest to date, an increasing number of projects involving tunneling or other significant subsurface work are already being delivered in the PPP mode.

Public owners have significant options to address risk allocation for subsurface conditions on PPP projects. The same sound and fundamental principles of fairness in risk allocation that apply in other major subsurface projects should be applied and adopted in the PPP context.

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Subsurface conditions risk allocation

The North American heavy construction industry has learned a number of fundamental risk management lessons during the last 30 to 40 years of underground construction practice. One key lesson is that risks associated with subsurface conditions on underground construction projects are significantly different, and much more difficult to predetermine, than risks associated with surface construction. This is due, primarily, to the inability to predict the nature of the subsurface conditions and ground behavior prior to the actual construction. Over the years, attempts by owners to unilaterally transfer subsurface risks to the contractor have been met with commercial, financial and political fallout for all parties involved. Owners have failed to have their facilities delivered on time or within budget. Contractors have lost money, their bonding capacity or their existence altogether. Engineering consultants have faced financial exposure because their professional service agreements expect them to be able to "see" underground and insurers have suffered losses when their contractor and engineering clients could not financially absorb the financial risks. To improve its worsening health and reputation, the tunneling industry developed a number of improved contracting philosophies and practices to cope with these unique risk challenges. These principles have been set out in publications by ASCE's Underground Technology Research Council, and have been endorsed on an international level by a number of British and international publications.

Improved contracting practices for subsurface construction

Central to fair risk allocation is that the owner ultimately owns the ground through which it wants its facility built. This responsibility comes with a number of distinct elements. First, owners are responsible for carrying out a thorough site exploration program, and documenting the results in a geotechnical data report (GDR) that is included in the contract. Second, the owner prepares an interpretation of the anticipated conditions and how those conditions will influence the construction. This interpretation is presented in a geotechnical baseline report (GBR), also included in the contract. The contractor is responsible for the construction-related risks associated with the conditions presented in the GBR, but is not required to carry contingencies in its bid for conditions more adverse than those presented in the GBR. If the contractor encounters conditions that differ materially from, and are more adverse than, those presented in the GBR, it is entitled to additional compensation attributable to the differences.

A number of other improved contracting practices have also been developed, such as escrow bid documents and dispute review boards, to aid the parties in meeting their contractual obligations under this risk management approach. The objective of these practices is to provide efficient, expeditious resolution of disputes that may arise during the course of the construction, thereby avoiding costly litigation and protracted dispute resolution processes using other dispute resolution techniques.

Nuances have evolved over the years relative to format and content for these different provisions, to reflect differences in the contracting methods, e.g., design-bid-build (DBB) versus design-build (DB). One nuance is with regard to how the GBR is prepared.

Geotechnical baseline reports

Having a GBR in the contract serves two primary objectives: to clearly allocate risks to the contractor for anticipated subsurface conditions; and to provide a basis by which the contractor may obtain additional compensation if it encounters unanticipated subsurface conditions. This is carried out in conjunction with a differing site conditions (DSC) clause in the contract. If there is no DSC clause, or if the owner does not intend to provide additional compensation for unanticipated conditions, the reasoning for inclusion of a GBR in the contract should be questioned. Assuming that the owner does intend to share risks as recommended by the improved contracting practices, there are a number of different ways that a GBR can be developed, depending on the form of contract used.

For DBB contracts, the owner prepares a 100-percent design (through its engineering consultant). The design may preclude the use of certain equipment and construction approaches, such as a nonpressurized face tunnel boring machine (TBM) or shaft supports consisting of dewatering with soldier piles and lagging. In this instance, the GBR is fully developed by the owner in a unilateral fashion, taking into consideration the owner's design and construction constraints and preferences. There is no opportunity for preconstruction bidder input other than through the standard request for information process.

Modifications to this approach can, and should, be implemented when the work is to be delivered using a DB approach. The same modifications are appropriate whether the project is being financed by the owner (the DB approach) or by a private financier/concessionaire (the PPP approach). The key is that in both instances, someone other than the owner is responsible for completing the design, not just the construction.

Whether DB or PPP, the owner will typically prepare a preliminary design as a reference design for bidding purposes, but the entire design and selection of construction means and methods will lie substantially with the competing contractor/engineer teams, not the owner. In either instance, the owner may impose the same limitations on design and construction approaches in its reference design and bid package. Relative to the GBR, it is recommended (Essex, 2007), in this instance, that the owner follows a collaborative rather than unilateral approach to finalizing the GBR as follows:

- The owner prepares an initial version of the GBR for bidding purposes that presents baselines of the relevant physical conditions to be encountered at the site. These physical conditions are independent of the different bidders' designs. The owner's GBR for bidding would leave gaps in the text, with guidance to the bidders on information that is to be provided in those gaps.
- In association with their bid preparation, each bidding team would answer the questions posed in the initial GBR, including their interpretation of the relevant physical conditions and behaviors consistent with their design and construction approach. This would include explanations for how specific risks are to be addressed during the work.
- In its evaluation of the different proposals, the owner has the latitude to question or seek clarification of certain statements or assumptions contained in each bidder's GBR responses. There might be a difference of opinion about the relative risks to be addressed, or it might just be a matter of clarifying a bidder's position on a certain approach. In either case, the owner would have the opportunity to discuss differences with each bidder to a point of mutual acceptance.
- Upon completing its review of the bidders' responses, and obtaining revised documents to reflect a common understanding of the matters at

issue (sometimes referred to as a "cure" period) the owner could then solicit financial bids for the project. In this manner, the owner would be in a better position to make an "apples to apples" comparison of the bids.

Risk allocation for subsurface conditions on PPP contracts

Risk allocation perspectives and dynamics in PPPs. Most public owners resort to the PPP approach because they lack sufficient funds to undertake the cost of designing and constructing a desired or needed project. As a general matter, many public owners perceive their objectives as best achieved by (a) minimizing retention and (b) maximizing transfer, or allocation to the concessionaire, of risk typically borne by the public owner. Put another way, the public owner seeks to significantly contain its risk exposure for cost overruns or schedule delays due to design and construction defects, events or conditions, such as the encountering of differing or unanticipated subsurface conditions.

The concessionaire may be willing to assume risk (such as for DSC) as a component of its base compensation. Presumably, the concessionaire's ability to price that risk derives from and should depend upon an adequate degree of reliable subsurface investigation available at tender. The concessionaire will plan to transfer down to the design-builder, on a back-to-back basis, risk (including subsurface conditions risk) that it assumes in the development agreement.

The financier will conduct some degree of due diligence to satisfy itself that the concessionaire is not assuming imprudent levels of risk that may impair the concessionaire's ability to complete the project on time and on budget. The source of payment of the concessionaire's loan obligation to the financier typically comes from a revenue stream from the completed project. As such, the financier will want to gain a reasonable degree of confidence that the concessionaire will "get to the finish line" and that the concessionaire's acceptance of imprudent types or degrees of risk do not unduly imperil or jeopardize that objective. The financier will also be keen to ensure that the concessionaire passes its design and construction risk downstream to the design-builder.

The public owner, concessionaire and financier perspectives on risk allocation and their aversion to cost overrun exposure together combine to exert substantial downstream risk transfer pressure to the design-builder.

PPP characteristics influencing subsurface conditions risk allocation

The previously discussed risk allocation perspectives and dynamics in PPPs present a challenging environment within which fair and balanced subsurface conditions risk allocation can exist, especially for the design-builder. Similar dynamics exist where public owners seek a DB delivery approach — they are increasingly adopting aggressive subsurface conditions risk allocation approaches on DB projects that would not be deemed acceptable by the industry under a DBB approach.

Beyond the foregoing considerations, there are distinguishing characteristics of PPPs that need to be taken into account relative to subsurface conditions risk allocation.

First, because PPPs are authorized by special enabling legislation, public owners often are exempt from otherwise governing risk allocation approaches (such as statutorily mandated inclusion of differing site conditions provisions). As such, public owners in PPPs generally have a broader range of discretion and judgment relative to risk allocation approaches than in more conventional delivery approaches. This can be good or bad depending upon the risk allocation decisions that are made.

Second, public owners, concessionaires and financiers — all keenly aware of the need to maintain cost and schedule control — view DSCs as a potentially major source of cost overruns and schedule delays and, as such, will seek to contain that risk exposure through contractual provisions that ultimately transfer substantial conditions risk to the design-builder.

Third, the public owner in a PPP project may not have the funds to commission an adequate subsurface investigation program prior to tender and/or may seek to eliminate any risk for subsurface conditions data or reports that it furnishes in a RFP by disclaiming the accuracy or completeness thereof and negating any right of the concessionaire or design-builder to rely upon those materials.

Fourth, since most public owners in PPPs do not have sufficient funds for design and construction, there are likely to be no contingency funds available to address the economic consequences of DSCs identified during design or encountered during construction.

Fifth, many public owners in PPPs rationalize more aggressive subsurface conditions risk allocation to the concessionaire and design-builder based upon the latter's responsibility for (a) defining the scope of and performing their own subsurface investigation program and (b) the development and finalization of design and construction approaches consistent with anticipated subsurface conditions. Further, public owners reinforce their more aggressive risk allocation positions on the recognition that there is a direct correlation and interdependency between the character of anticipated subsurface conditions and the achievability of project design and contemplated means and methods (including equipment selections) to be used in the construction process.

Application of improved contracting practices to PPP projects

Improved contracting practices — including the hallmark and fundamental principle of fairness in risk allocation for subsurface conditions — should be applied and adapted in PPP projects.

There are several major PPP and DB projects presently in progress in which a range of risk allocation approaches to subsurface conditions have been adopted. These projects include:

- Port of Miami Tunnel (PPP).
- Virginia Midtown Tunnel (PPP).
- Evergreen LRT in Vancouver (DB).
- Ottawa LRT (PPP).
- Ohio River Bridges East End Project (PPP).
- Eglinton-Scarborough Crosstown LRT (PPP).
- Alaskan Way Viaduct Replacement Tunnel (DB).
- Niagara Tunnel (DB).
- Lake Mead No. 3 Intake Project (DB).
- Trans Hudson Express Tunnels (DB) *project terminated.

Each of these projects has approached risk management aspects of subsurface conditions in a different manner:

- Use of a geotechnical data report — Some have included the document but through exculpatory language have denied the right to rely on the information as a basis for a DSC.
- Use of a geotechnical baseline report — Some have engaged bidders in a collaborative process (e.g., Niagara Tunnel), while others have solicited comments and suggested modifications from bidders in their proposals. Others have included a GBR purely as a means of allocating risks to the designer- builder, with no responses accepted and no DSC clause in the contract. Some have sought to limit the risks of a DSC by limiting the baseline conditions to a narrow zone around the planned excavated opening, thereby disavowing the accuracy and behavioral influence of any ground beyond (above and below) the baselined zone. The latter approach appears to be the horizontal equivalent of limiting the accuracy of a borehole to the cylinder of ground through which it was drilled.
- Disclaimers that shed disproportionate risks to the contractor or PPP team, either through words or odd baseline geometrics such as those described above.
- Use of escrow bid documents (EBDs) — Some have included EBDs, some have not.
- Use of dispute review board (DRB) — Some have included a DRB, others have excluded this or any other form of disputes resolution.
- Financial risk sharing — Some projects have acknowledged that conditions more onerous than the baselines are compensable by the owner, whereas others have asserted that all risks associated with unforeseen conditions are to the bidder's account. Several have adopted a ladder-rung form of financial responsibility, where an initial dollar volume is to the bidder's account, a second dollar volume is to the owner's account, and amounts above those two are to be shared by the bidder and owner according to a specified percentage split.

Project owner decisions in these respects are having a material impact on subsurface conditions risk allocation —in some cases dispensing with risk sharing altogether.

Conclusions and recommendations

With the growing number of tunnel projects being delivered through DB and PPP contracts, the doctrine of fair contracting through an equitable sharing of risks associated with subsurface conditions is quickly being eroded. Project owners are driving the tunneling industry in a backward direction by using unfair and unbalanced risk allocation approaches. In several cases, the industry has returned to the "you bid it, you build it" standards of the 1970s.

The concern is that unanticipated subsurface conditions during construction will lead to delays and disputes that will find their way to the newspapers and industry magazines, and controversies will build once again relative to the ability of the tunneling industry to "deliver." That DB or PPP contracting methods are being used will be irrelevant to the impacts of bad press.

The authors recommend that organizations such as the Underground Construction Association of SME, ASCE's Construction Institute and the International Tunnelling Association engage in dialogue with project owners, financiers, insurers, contractors and engineers to help steer the industry back to more appropriate means of managing risks associated with subsurface conditions on PPP (and DB) projects.

Those familiar with what happened to the Australian tunneling industry in the 1980s-1990s will appreciate what is in store for the U.S. tunneling industry if the trend away from fair contracting practices continues. ■

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FEATURE ARTICLE

Record attendance for 2014 George A. Fox Conference

The 2014 George A. Fox Conference at the Graduate Center, City University of New York in New York City was presented under the theme, "21st Century Challenges for the Tunneling Industry."

Bruce Grewcock, chief executive officer and president of Peter Kiewit Sons' Inc., opened the conference with a keynote address in which he set the tone for the rest of the day by touching on the many challenges the industry is facing, which are plentiful and complex.

Covering the breadth of the industry, he spoke about everything from the technical challenges that come from working beneath the streets of some of the most densely populated regions in the world to the challenges that come from working with the people who live in those areas.

"My observation is that we, as an industry, are being asked to put structures in places where they are needed, but are complex environments to work in," said Grewcock. "We work in an industry that relies on some of the most technically challenging engineering in the world, and when we are done with a project, we cover it up and no one ever sees it."

Despite these issues, Grewcock said that, in his opinion, the biggest challenge the industry is facing is that of people; more precisely, where to find the next batch of people. Looking out at the conference-record crowd of more than 400 registered attendees, Grewcock quipped that he saw plenty of gray beards and asked aloud, "Where will we find, educate and train the people to tackle the issues that this industry will face in the future?"

In his opinion, the future of the underground construction industry is robust and positive despite any short term doldrums the industry might currently be facing. Citing reasons for the positive long-term outlook, he noted that, in 2014, there will be a record of more than 965 km (600 miles) of tunnels bored world wide. There continues to be increased urbanization in the United States and around the world, and with that there is a continued push for improved transportation structures and a need to improve aging infrastructures.

Grewcock even gave a nod to the U.S. Environmental Protection Agency, saying that the agency is sending plenty of work to the underground construction industry by way of legislation demanding improved water tunnels in many urban areas.

William Gleason, Senior Editor

The challenges to meet the demands Grewcock laid out are significant and complex and must be taken seriously by those in the industry. The SR99 tunnel in Seattle, WA, for instance, is a massive project with unique challenges that range from varied ground conditions and unforeseen obstructions to legal and community affair issues that had to be addressed before ground could ever be broken for the project.

Bruce Grewcock, chief executive officer and president, Peter Kiewit Sons' Inc., discussed the challenges facing the industry during his keynote address to the 2014 George A. Fox Conference in New York City.

The next generation of professionals will have to have a skill set that allows them to understand and address all of these areas.

To that end, Grewcock plugged an initiative that is taking place at the Colorado School of Mines to create skilled employees through the Center for Underground Construction and Tunneling, directed by Mike Mooney.

The center aims to prepare students for the challenges of the industry by recruiting from a collaborative, interdisciplinary group of faculty and students from the departments of civil and environmental engineering, geology and geological engineering, mining and mechanical engineering, as well as geophysics and computer science.

While the training that is taking place at the Colorado School of Mines, and other institutions, is educating and training people for the foreseeable challenges that lie ahead, there are, occasionally, challenges that cannot be anticipated or controlled. One of those came in the form of Hurricane Sandy.

In October 2012, the northeast region of the United States was hit hard by the storm that proved to be the deadliest and most powerful storm of 2012. It was responsible for the deaths of 117 people in the United States and 69 more in Canada and the Caribbean.

It was the second most costly storm in the history of the United States. When the storm hit the United States on Oct. 29, it affected 24 states, with particularly severe damage in New Jersey and New York.

The brunt of the storm brought waves nearly 4.2 m (14 ft) high to Battery Park in Manhattan, flooding streets, tunnels and subway lines and cutting power in and around the city.

Damage in the United States has been estimated to be $65 billion.

In regard to New York's extensive underground network, the Brooklyn Battery Tunnel was hit the hardest by the storm.

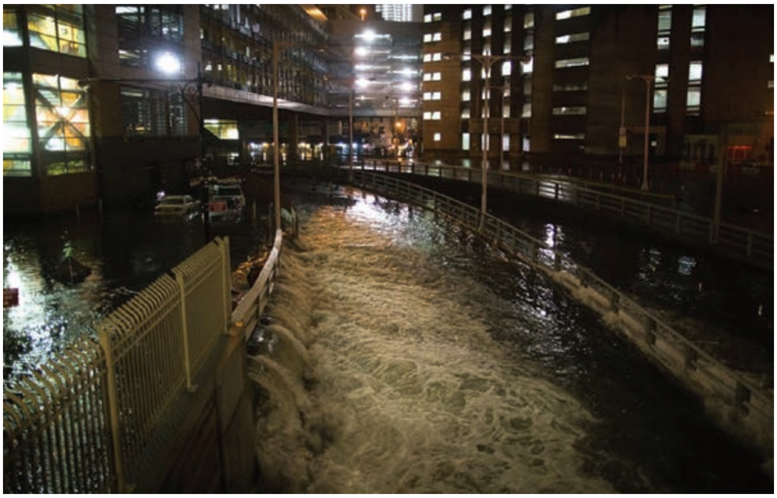
More than 65 percent of the longest traffic tunnel in the United States was flooded by more than 60 million gal of seawater.

The nearly 3.2-km (2-mile) long tunnel that opened in 1915 is a critical tunnel to the region, and, when the seawater flowed into the tunnel, it affected every aspect of the structure including the lighting, pumping stations and communications.

Romolo Desantis, director/Sandy programs for MTA TBTA and David Field, vice president, Hatch Mott MacDonald, spoke about the efforts to first dewater the tunnel and return it to service, which was completed on a limited basis on Nov. 12 and completely on Dec. 10, to the restoration process that is being headed up by Hatch Mott MacDonald.

The restoration improvements will include a new fireline, a number of safety improvements, new exit lights and the replacement of approximately four million tiles, Field said.

This photo from *Business Insider.com* shows seawater entering the Brooklyn Battery Tunnel on Oct. 29, 2013 from Super Storm Sandy.



International projects

While much of the conference was dedicated to tunneling projects in the northeast region of the United States (2nd Ave. Subway in New York, the Northern Boulevard section of New York's East Side Access Project and Amtrak northeast tunnel project), it was also pointed out that the challenges the underground construction industry faces are not unique to the United States. Some of the challenges faced by international projects were discussed in the afternoon session of the conference.

David Whittaker, delivery manager, Thames Tideway Tunnel, spoke about the massive combined sewer overflow (CSO) efforts being taken on London's Thames River.

The issues of pollution flowing in to the river is centuries old. The current sewer system in London is 100 years old and in desperate need of improvement. Each year, an estimated 39 Mt (43 million st) of CSO discharges into the river with an average discharge of once a week.

In an effort to alleviate this, the Thames Tideway Project will be constructed in three phases. The first two phases, the construction of the 3.2-km (4-mile) Lee Tunnel and upgrades to London sewer works, are already underway. The final phases will be the construction of the 25-km (15.5-mile) long Thames Tunnel that will improve 34 existing CSO sites.

Working with the Environment Agency in London to identify the most polluting CSOs – the ones that cause unacceptable environmental impacts because of the frequency or volume of the overflow, or because they discharge into an environmentally sensitive part of the river – the project will address the overflows from these CSOs, either by directly connecting them to the tunnel, or by making other alterations to the sewerage system that will use the existing capacity more effectively.

The flows diverted into the tunnel will be stored in the tunnel and pumped out for treatment at Beckton Sewage Treatment Works in east London.

The CSOs will still be needed after the Thames Tideway Tunnel has been built to direct flows to the River Thames in exceptional circumstances when the new tunnel system is full.

The technical challenges of such a project are immense, as are the social and legal challenges.

Whittaker said the US$6.7 billion project will affect 14 London borroughs, and noted that the application for development includes 50,000 pages.

Other international projects discussed included Gerhard Urschitz, managing director, Strabag AG speaking about the Koralm Tunnel project in Austria. Jon Hurt, principal, Arup, spoke about the Billy Bishop Tunnel in Toronto and Brian Garrod, executive vice president, HHM, gave a presentation about the Elington Subway extensions in Toronto.

This year the conference included a panel discussion surrounding public, private parternships (PPP) that included David Corkum and David Hatem, partners, Donovan Hatem, LLP; Urschitz and Craig Covil, principal, Arup. This issue is dicussed at length in the feature on page 66 coauthored by Hatem and Randy Essex.

The George A. Fox Conference will return to the Graduate Center, City University of New York on Jan. 27, 2015. ■

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	Under design
Water Tunnel #3 Stage 3 Kensico	NYC-DEP	New York	NY	Water	84,000	20	2017	Under design
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Highway	25,000	30	2016	Under study
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2018	Under design
Hartford CSO	MDC	Hartford	CT	CSO	32,000	20	2014	Under design
South Conveyance Tunnel	City of Hartford	Hartford	CT	CSO	16,000	26	2015	Under design
Red Line Tunnel - Cooks Lane Tunnel	MD Transit Administration	Baltimore	MD	Subway	14,000	22	2015	Under design
Red Line Tunnel - Downtown Tunnel	MD Transit Administration	Baltimore	MD	Subway	36,000	22	2015	Under design
Purple Line - Plymouth Tunnel	MD Transit Administration	Baltimore	MD	Subway	1,000	30x40	2015	PPP - RFQ 12/10/13
Northeast Branch Tunnel Northeast Boundary Tunnel	DC Water and Sewer Authority	Washington	DC	CSO CSO	11,300 17,500	15 23	2018 2021	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
Dugway Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,000	24	2014	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
Big Creek Storage Tunnel	NEORSD	Cleveland	OH	CSO	19,500	20	2026	Under design
Ohio Canal Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,170	27	2015	Under design
Northside Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,850	24	2021	Under design
Continental Rail Gateway	CRG Consortium	Detroit	MI	Rail	10,000	28	2015	Under design

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
ALCOSAN CSO Program	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	35,000	20	2016	Under design
Lower Pogues Run	Indianapolis DPW	Indianapolis	IN	CSO	9,700	18	2018	Under design
Fall Creek	Indianapolis DPW	Indianapolis	IN	CSO	19,600	18	2016	Under design
White River Tunnel	Indianapolis DPW	Indianapolis	IN	CSO	27,800	18	2016	Under design
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	Under design
East Link Light Rail Extension	Sound Transit	Seattle	WA	Transit	30,000	22	2016	RFQ underway
L.A. Metro Regional Connector	Los Angeles MTA	Los Angeles	CA	Subway	20,000	20	2014	Awaiting award
L.A. Metro LAX to Crenshaw	Los Angeles MTA	Los Angeles	CA	Subway	12,200	20	2013	Walsh/Shea 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 2015 2017	Bid date 12/14/13 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	2014	RFQ underway
River Supply Conduit - Units 5 and 6	LA Dept. of Water and Power	Los Angeles	CA	Water	8,608	12	2014	Bids 03/04/2014
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	L.A. Dept. of Public Works	Los Angeles	CA	CSO	37,000	18	2015	Under design
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2016	Under design
SVRT BART	Santa Clara Valley Trans. Authority	San Jose	CA	Subway	22,700	20	2014	Under design/ delayed
BDCP Tunnel #1 BDCP Tunnel # 2	Bay Delta Conservation Plan	Sacramento	CA	Water	26,000 369,600	29 35	2015 2017	Under design Under design
Yonge St. Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2016	Under study
Hanlan Water Tunnel	Region of Peel	Toronto	ON	CSO	19,500	12	2013	Southland/ Technicore low bid
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

LOCAL SECTION NEWS

CSM students tour the world's largest bored-tunnel project

Nineteen undergraduate and graduate students from the civil, geological, mining and mechanical engineering departments of Colorado School of Mines (CSM) traveled to Seattle, WA to visit the largest tunnel boring machine (TBM) tunnel project in the world. The 17.5 m (58 ft) diameter TBM is carving a 3.2 km- (2-mile) long tunnel through downtown Seattle as part of the SR99 Alaskan Way Viaduct Replacement project site.

Students included undergraduates Justin Downs, Stephanie Ecker, James Halverson, Erin Keogh, John Kuyt, Mark Landman, Heather Mergentime, Fausto Moraes and Stephen Semmens, and graduate students Ian Donovan, Robert Godinez, Mason Kreidler, Lisa Mori, Eric Poeck, Simon Prassetyo, Brock Rysdahl, Kevin Schaeffer, Daniel Cano and Erick Wilkins. The trip was organized and financially supported by the Center for Underground Construction & Tunneling at CSM.

Many of the graduate students who traveled with the group took the Analysis and Design of Tunnels in Soft Ground course taught by CSM Professor Mike Mooney, in which they completed academic designs of many aspects of the double-decker traffic tunnel. The tour provided a unique and valuable experience to compare what was analyzed and developed in the classroom with the actual, implemented design.

In addition to touring the SR99 project site, students visited a 6 m- (20 ft-) diameter metro tunnel and station under construction by Sound Transit. Juxtaposing visits to the two different projects provided the students with a rich educational experience.

The students also attended presentations by Seattle Tunnel Partners, the project design-build team, and by the Washington State Department of Transportation, the project owner. ■

CSM students visit the SR 99 Alaskan Way Viaduct Replacement project site in Seattle, WA.

PERSONAL NEWS

ILF Consultants has appointed **CONRAD W. FELICE** as president and chief executive officer and **JAMES A. MORRISON** (SME) as executive vice president. Each brings more than 30 years of expertise in tunnel and underground systems, geotechnics and foundation engineering applied to the energy, water, mining and natural resource markets.

Jacobs Associates has chosen **JOEL KANTOLA** P.E. and the late **BHASKAR THAPA** P.E. as the 2013 recipients of the James Wilton Award. Kantola is a senior associate in the Boston office and Thapa was a lead associate in the Walnut Creek office. The award honors the memory of James Wilton, former principal and president of Jacobs Associates and recognizes the accomplishments and contributions made by Jacobs Associates employees. It was presented on Oct. 25 in Scottsdale, AZ. Kantola has more than 20 years of civil engineering experience in design, analysis, claims and construction. As part of the DC Clean Rivers Project, he has been a project manager on the Anacostia River Tunnel and assistant project manager on the Blue Plains Tunnel. He is currently working on the 823 m- (2,700 ft-) long First Street Tunnel.

KANTOLA

THAPA

PERSONAL NEWS

Thapa had more than 14 years of experience in the design and construction of underground structures. He was an expert in the New Austrian Tunneling Method (NATM), and was the lead tunnel designer and the design representative during construction on the Caldecott Improvement Project.

LINDSAY

Jacobs Associates recently expanded its Midwest operations by opening an office in St. Louis, MO. The new office will allow the firm to provide services more efficiently to clients requiring tunneling and underground expertise throughout the central United States. The office will be headed up by senior associate **WAYNE LINDSAY**, who joined the firm in December 2013. Lindsay has been in the consulting industry for more than 25 years, with a focus on water and wastewater infrastructure projects. He is a marketing expert in program and construction management, alternative delivery, and planning and design of large multiyear programs around the country.

The San Francisco Public Utilities Commission (SFPUC) announced the selection of **DANIEL L. WADE** P.E. as the new director of the agency's Water System Improvement Program (WSIP). The WSIP includes 82 water infrastructure projects, including the construction of a new dam, three tunnels, an ultraviolet treatment facility, large-diameter pipelines, as well as the rehabilitation and upgrades of existing storage, treatment and transmission facilities. He replaces **JULIE L. LABONTE**, who held the position for seven years. In his new role, Wade will oversee the entire program, including four geographic regions with 16 projects currently under construction totaling approximately $2.7 billion. For the past six years, he served as the regional project manager for the Sunol Valley projects within the WSIP. ■

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Iguassu Falls - Brazil Contact: Executive Secretariat, Phone/Fax: +55 11 3868 0726, email info@wtc2014.com.br; web www.wtc2014.com.br.

19-21 • Ground Improvement in Underground Construction and Mining

Colorado School of Mines, Golden, CO. Contact: Levent Ozdemir, Phone: 303-526-1905, email: lozdemir1977@aol.com; web www.csmspace.com/events/grndimprovsupt/. ■

UCA of SME

North American Tunneling Conference
June 22-25, 2014
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900 W. Olympic Blvd.
Los Angeles, CA

George A. Fox Conference
Jan. 27, 2015
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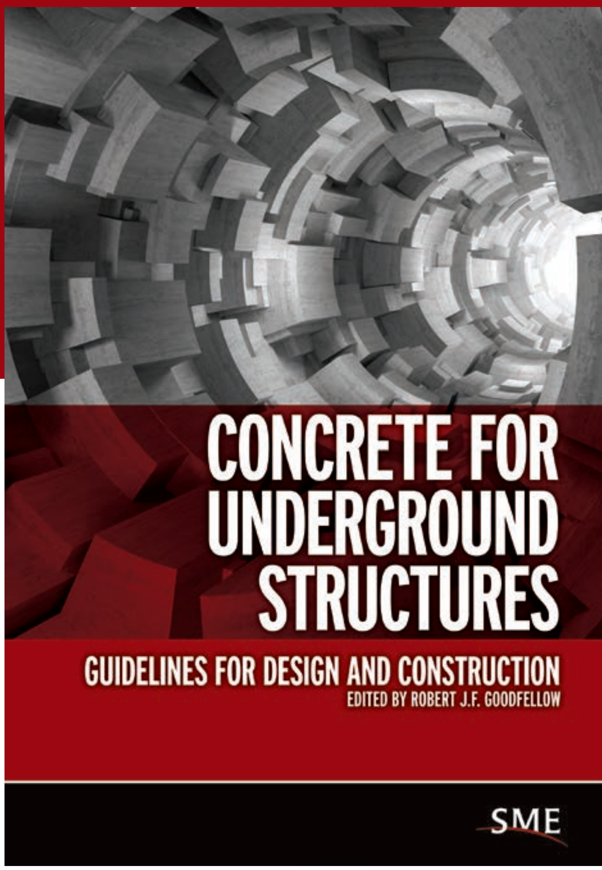
CONCRETE FOR UNDERGROUND STRUCTURES

GUIDELINES FOR DESIGN AND CONSTRUCTION



CONCRETE FOR UNDERGROUND STRUCTURES: GUIDELINES FOR DESIGN AND CONSTRUCTION

EDITED BY ROBERT J.F. GOODFELLOW

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Concrete is a vital component of almost every underground construction project. Because it significantly impacts both the durability and cost of a project, owners, designers, and contractors are constantly challenged with designing and placing the concrete to meet their quality standards in the most cost-effective way.

Concrete for Underground Structures: Guidelines for Design and Construction can make that task a lot easier. Instead of searching pages of scattered reference materials when writing specifications, this book is a one-source guide to help you quickly find the answers you need.

The first resource of its kind, this practical nuts-and-bolts handbook provides an industry voice as well as recommendations for areas of concrete application. You'll get valuable insights into current best practices for all aspects of the design and construction of underground structural concrete.

Internationally respected authors examine three key applications: cast-in-place concrete, precast concrete segmental linings, and shotcrete. Each chapter addresses the differences between aboveground and underground use. The various types of concrete admixtures are also discussed, and sample specifications for each are included.

Concrete for Underground Structures is an indispensable resource for industry veterans as well as an educational tool for those who are new to the profession.

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