T&UC

TUNNELING & UNDERGROUND CONSTRUCTION

THE OFFICIAL PUBLICATION OF UCA OF SME WWW.TUCMAGAZINE.COM VOLUME 4 NO 4 DECEMBER 2010

Sound Transit University Link

On time project delivery

Tunnel demand forecast

Special Editorial Section from the publisher of *Mining Engineering*

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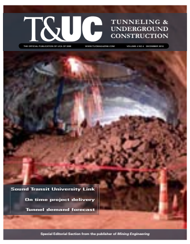
COVER STORY



COVER — This month's cover shows the Weehawken Light Rail project in Jersey City, NJ, where workers are adjusting the reinforcing steel connections for one of the stations. The photo is part of the 2010 UCA of SME calendar. Some of the photos deserve a wider audience, so *T&UC*, on occasion, will publish some of the calendar photos on its cover. Photo courtesy of George Yoggy.

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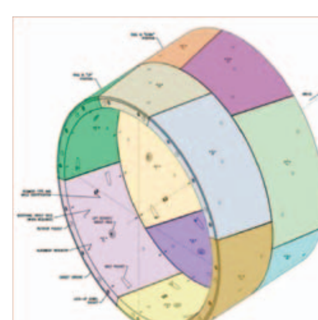

DEPARTMENTS

Special editorial section from the publisher of *Mining Engineering*

CHAIRMAN'S COLUMN

Underground construction industry has been on wild ride recently

The underground construction industry has had a tumultuous time since my last column that was written in August. We have had a national election that will impact our industry in positive and negative ways. And we have seen the cancellation of a major underground construction program when the governor of New Jersey announced his intent to cancel the New Jersey Transit Access to the Region's Core (ARC) program. In my opinion, the underground construction industry remains strong, as there are many ongoing and upcoming programs and projects that continue to make our industry vibrant when compared to other aspects of the construction industry.

The Nov. 2 general election is sure to have an impact on our industry. The new Congress that will be seated may not be as "willing" to fund new projects as has occurred during the past years. High speed rail programs in various states might be among the projects impacted by the election, as some elected governors and House members campaigned against these programs. As I travel across the U.S. and visit various contractors and designers, I have found that, contrary to the belief of the general populace, the American Recovery and Reinvestment Act (ARRA) program has had a marginal benefit to our industry. A few major projects were funded by ARRA. But, in general, tunnel projects have been reliant on traditional funding sources for financing. An interesting statistic is that, of the $787 billion in the ARRA Bill, only 21 percent was allocated to all types of construction, and some of these funds have not yet been allocated.

The actions taken by New Jersey Gov. Chris Christie have many of our members bewildered, as everyone thought this program was fully funded and advancing forward. The reason given for the cancellation was a potential cost overrun that would be the responsibility of the people of the state of New Jersey (see page 3). I can understand this concern, but it would be interesting to see the report that was the basis for the governor's decision. There is industry concern that the final cost to build was based on computer modeling that escalated construction costs that had already included cost escalations based on the nature of the project and length of time to construct. Many of us in this business have invested considerable amounts of time and money meeting with the design engineers and owners to freely dispense information and suggestions under the pretense that there would be a project from which we could recover our costs and make a potential profit. How do we recover these costs?

Despite the cancellation of the ARC project, the industry is still advancing. Price and technical proposals were made in late October for the Washington DOT Alaskan Way Tunnel Project in Seattle, WA. Based on a news release from the owner, both design-build proposals received and were within the agency's budget. Thus, both proposals will be evaluated and an announcement on a project awardee will be made before the middle of December. Other major tunnel projects were bid during the quarter in Cleveland, OH and Austin, TX. Please refer to the Tunnel Demand Forecast in this issue for additional upcoming projects (page 52).

During the next UCA of SME Executive Committee meeting in late January, we will be selecting our UCA 2011 awardees and Project of the Year. If you have a person or project that you would like to

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David R. Klug,
UCA of SME Chairman

New Jersey governor kills ARC project

What was to be the largest public works project in the United States was killed by New Jersey Gov. Chris Christie who, on Oct. 7, cancelled the $8.7 billion Access the Region's Core (ARC) tunnel project.

Citing escalating cost estimates of $2.3 billion to $5.3 billion over the estimated total, Christie announced the cancellation of the project, *The New York Times* reported.

"There has not been significant change in those $2 billion to $5 billion numbers," said Christie. "This was a project that had the potential for crowding out everything else that New Jersey is trying to do regarding fiscal responsibility. The potential for $2 billion to $5 billion cost overruns was something that was unacceptable for me to contemplate, knowing that it was just the beginning, potentially, of what this project would cost."

The Trans-Hudson Passenger Rail Tunnel, planned for about 20 years, was meant to add a second pair of tracks between New Jersey and Manhattan. Currently, about 275,000 people from New Jersey commute across the Hudson River to New York every day. During rush hour, Amtrak and regional trains are full and the two Hudson River tunnels are near, or at capacity. The third tunnel would provide room for 70,000 more New Jerseyans to reach Manhattan each day (*T&UC*, March 2009, page 22).

The ARC tunnel would reduce traffic congestion and pollution, shortening commuting times, increasing suburban property values and creating 6,000 construction jobs along the way.

Christie argued that the renovation of the Portal Bridge that runs from Kearny to Secaucus over the Hackensack River, an essential part of the project, was not included in the initial estimates. That project alone, he said, would add an additional $800 million to the price tag.

The project broke ground in 2009 and was expected to be finished in 2018.

Billions of dollars had already been committed to building the tunnels. The federal government had promised $3 billion in federal money. The Port Authority pledged another $3 billion, about half of which is money normally dedicated to New York state, and New Jersey was supposed to commit at least $2.7 billion in stimulus and turnpike funds.

In September, Christie halted spending on the tunnel. Officials at New Jersey Transit, the project's overseer, said they had placed a 30-day moratorium on all new work and contract bids until they could determine if the project's cost would be covered by its budget. The review was prompted by months of talks with federal officials concerned about cost overruns.

In early October, Christie said he was canceling the project because his staff had concluded it would cost more than $11 billion and possibly as much as $14 billion. At the request of the federal transportation secretary, Ray LaHood, Christie agreed to a further two-week review. LaHood came back with a different set of numbers that gave a cost range of at least $9.775 billion and possibly more than $12 billion.

On Oct. 27, Christie said that was still too much, and reaffirmed his decision to cancel the project. ■

Two teams remain in bid for Alaskan Way project

With just two construction teams, the Seattle Tunneling Group and Seattle Tunnel Partners, left in the bidding process for the Alaskan Way viaduct replacement project, Washington state sweetened its Highway 99 tunnel contract by offering the pair of bid teams $230 million in concessions.

The changes reflect a view by construction executives that the real costs of the project are higher than the state projected several months ago, *The Seattle Times* reported.

The money for the concessions can be shifted out of a large pool of risk and contingency funds, so the overall tunnel budget remains $1.96 billion, said Ron Paananen, state program administrator.

The Seattle Tunneling Group is made up of S.A. Healy Co., from Lombard, IL.; Spain's FCC Construction; S.A. Parsons Transportation Group, which has a Seattle office and Halcrow, which has an office in Vancouver, B.C.

Seattle Tunnel Partners is made up of Dragados-USA, from New York HNTB Corp., which has a Bellevue, WA office, and Tutor-Perini Corp. of Sylmar, CA.

"The best thing to me about all this is there are two very serious teams," said Dick Page, district leader for HNTB, the engineering managers for Seattle Tunnel Partners.

Tunnel boring machine (TBM) manufacturers were also in the bidding process for the project that will include a 16.7-m- (55-ft-) diameter tunnel that will carry four lanes of traffic from the stadiums to South Lake Union, replacing the old Alaskan Way Viaduct.

To keep both construction teams in play, *The Seattle Times* reported that the state offered three allowances in a series of contracting

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World's longest tunnel completed

Miners met for the final breakthrough of the world's longest tunnel, the Gotthard Base rail tunnel in Switzerland, on Oct. 15 when the tunnel boring machine drilling from Faido broke through. The breakthrough happened 30 km (18 miles) from the north portal and 27 km (17 miles) from the south. The tunnel breakthrough was highly accurate at 8 cm (3 in.) horizontally and 1 cm (0.4 in.) vertically.

The twin-tube, single-rail tunnel is 57 km (36 miles) long connecting the Swiss towns of of Erstfeld, north of the Alps, with Bodio, on the southern side. With a rock overburden of up to 2,500 m (8,200 ft), the Gotthard base tunnel is also the most deeply set rail tunnel in the world. Together with the 15.4 km (9.5 mile) Ceneri base tunnel, the Gotthard base tunnel will provide a level track through the Alps. The Base tunnel through the Gotthard is the core of the new rail connection. It is planned to become operational by the end of 2017. It is designed to carry international 250-km/h (155 mph) high-speed trains. The price tag for the project is around 10 billion Swiss francs (US$10.4 billion).

The trans-alpine rail connection "is a key project for sustaining the long-term viability of both passenger and goods traffic," said Manfred Schellhammer, managing director of freight and logistics company Kuehne & Nagel International AG, *The Wall Street Journal* reported.

The first works were carried out in 1993, with the Piora exploratory boring, and from 1996 to 1998 with the blasting of the access shafts in Sedrun, Faido and Amsteg. Since 2001, the main lots have been constructed. The final breakthrough in the west tube is planned to take place in April 2011.

Some 2,500 miners, drawn from all over Europe, as well as from countries with mining expertise like South Africa, have worked around the clock to move around 24.5 Mt (27 million st) of rock and rubble from the twin tunnels.

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Alaskan Way tunnel project

(Continued from page 3)

updates issued earlier:

- The state will pay the winning tunnel team $110 million to cover inflation.
- The state will reimburse the team an additional $100 million for bonds and insurance, an indication of the risky nature of boring such a large tunnel beneath downtown Seattle, in soils that are watery or abrasive in spots. Teams must obtain a surety bond to guarantee a half-billion-dollar restart if the cylindrical drill gets stuck mid-project, or if a new contractor must step in.
- $20 million "deformation allowance" would fix buildings that are damaged, if the tunnel drilling causes soil to settle. The Department of Transportation (DOT) identified five structures that require reinforcement, such as steel or concrete beams, and 34 that require concrete grouting to reinforce the earth. Also, the tunnel passes below the old Viaduct foundations.

Paananen said managers expected all along to make these or similar kinds of adjustments before the bids came in.

They are designed to reduce the companies' risk, so bids are more likely to meet the target price of $1.1 billion, published many months ago.

On the upside, Paananen said, the state will recoup $50 million from the city of Seattle for utility relocations in parts of the 2.7-km (1.7-mile) tunnel corridor, a figure that was not budgeted earlier.

After all the changes, the state DOT's original $415 million cash reserve stands at about $235 million — to cover potential cost overruns. Paananen said the figure is still above the 10 percent a DOT expert panel suggested.

Other enticements might also be offered, including a reimbursement because DOT moved the south tunnel entry 182 m (600 ft), an allowance if the tunnel machine does not require costly repairs in the ground, and an incentive payment to finish the job before November 2016. ■

Correction

In the September issue of *T&UC*, it was incorrectly reported that a tunnel boring machine (TBM) had been chosen for the Alaskan Way Viaduct (*T&UC*, Sept. 2010, page 6). Several TBM manufacturers are still in close discussion with the remaining contractors. At this time, neither contractor being considered for the job has selected a TBM manufacturer for the project and the TBM decision will not be decided until contracts are officially awarded. ■

Rio Tinto teams with Aker Wirth on new tunneling solution

As part of its Mine of the Future program designed to improve the construction of underground mines, Rio Tinto partnered with Aker Wirth to develop a new underground excavation system. The first of three of these tunnel boring systems has been made ready for full scale performance verification trials in 2012 at Northparkes' copper and gold mine in the Central West of New South Wales.

Rio Tinto head of innovation, John McGagh, said the significant new investment offers the possibility for a step-change improvement over conventional drill-and-blast practices.

"Depending on rock conditions, this system should provide a capability to excavate at more than double the rate of conventional methods," McGagh said in statement released by Rio Tinto. "For example, in a typical deep copper orebody, the rate of horizontal tunneling could be as high as 10 to 13 m/d (33 to 43 ft/day) using this new system.

"Aker Wirth is one of three partners with whom Rio Tinto is working to develop new equipment and systems for the rapid construction of deep underground mines," he said.

This new tunneling boring system trial has been integrated into a previously announced $90 million prefeasibility expansion study at Northparkes in August 2010 by Northparkes' joint venture partners Rio Tinto and Sumitomo Group companies.

McGagh said the trial will complete the final stage of performance verification of the new system.

The Mine of the Future program aims to enable Rio Tinto to more effectively carry out exploration; more efficiently exploit resources; and to allow safer, faster and deeper underground operations while economically recovering valuable mineral resources from increasingly difficult deposits.

"We are proud to have been selected by Rio Tinto as a partner in this ambitious project," Aker Wirth chief executive officer Christoph Kleuters said. "This system confirms Aker Wirth's commitment to maintain our position as a technology leader in hard rock excavation for the underground mining and tunnelling industry."

"This is about The Mine of the Future program going underground, as we promised we would at the start of 2010," McGagh said. "This system incorporates continuous mechanical rock excavation that will not damage new tunnel walls, while still providing the ability to mechanically install ground support in parallel with tunnel advance. Importantly for Rio Tinto, it provides an opportunity to introduce fundamentally safer processes into the underground mining industry."

The new tunnel boring system is expected to arrive in Australia in early 2012, and be operational with trials completed at Northparkes by the end of 2012. The system is 64-m- (210-ft-) long, has a maximum boring diameter of 6 m (20 ft) and has minimum tunnel dimensions of 5 m x 5 m (16 ft x 16 ft). After the trial, this technology is destined for use in other Rio Tinto underground mining operations internationally. ■

Design phase begins on Ohio tunnel

Black & Veatch has begun planning for the Lower Mill Creek Tunnel, a $244-million, 1.9-km (1.2-mile) tunnel system, pump station and enhanced high-rate treatment facility in Cincinnati, OH.

The project could reduce the mixture of sewage and stormwater that enters local waterways, improving the quality of life for the more than two million people living in the metropolitan area.

It could be a part of the Metropolitan Sewer District of Greater Cincinnati's Project Groundwork, a multi-billion dollar and multi-year public works program that will reduce combined sewer overflows by 85 percent and eliminate all sanitary sewer overflows.

The Metropolitan Sewer District is also exploring alternatives or supplements to the tunnel.

"Tunnel design and implementation for reducing sewer overflows is a steadily growing practice at Black & Veatch," said Dan McCarthy, president and CEO of Black & Veatch's global water business. "We expect this growth to continue as more cities – both large and small – work to reduce their sewer overflows." ■

Sound Transit agrees to pay for damaged home

As many as seven underground voids were formed by shifting soils as a result of twin light rail tunnels in Seattlle's Beacon Hill area.

Because of these voids, Seattle's Sound Transit paid $400,000 to buy a Beacon Hill property where two large holes formed.

Owners Rommel Panganiban and Christine Miller-Panganiban filed a claim for damages after two underground voids were discovered on their property in March 2009. Engineers later found a second one, and then uncovered seven more voids deeper underground along the tunnel's path, *Seattlepi.com* reported.

As part of a settlement, Sound Transit agreed to purchase the home located about 41 m (135 ft) directly above the tunnel that carries northbound trains. In addition, the agency agreed to pay $11,350 for a construction easement for prior work on the property and $65,000 in damages for "loss of quiet enjoyment and claims of emotional distress," according to terms of a Sept. 10 settlement agreement.

The voids resulted from shifts in layers of sand caused by the over-excavation with the tunnel-boring machine. Construction of the tunnels ended more than two years ago. For the past year, Sound Transit crews have been drilling and probing for more potential voids.

The first hole was about 6 m (20 ft) deep. Crews filled the voids with a quick-setting, cement-based filler. Other areas of loose soil around the voids were compacted by pumping cement grout through a pattern of drill holes near the locations.

Sound Transit spokesman Bruce Grays said the agency intends to recoup the money from the contractor, Obayashi Corp. Sound Transit is still investigating and plans to do more drilling work on the property, he said. The home will be resold in the future, he said.

Sound Transit's governing board authorized up to $4 million on void remediation, with about $2 million spent so far.

The voids demonstrate the risks with tunneling in this area. The state transportation department expects to encounter similar soil conditions along the path of the deep-bore tunnel that is planned to replace the Alaskan Way Viaduct. ■

Gotthard Tunnel

(Continued from page 4)

About 13.3 million m^3 (469 million cu ft) of aggregate, enough to build the equivalent of five Giza pyramids, have been excavated since the tunneling began, and eight miners have died.

The Swiss approved the project in a 1998 referendum in an effort to alleviate the environmental and logistical problems caused by a surge in heavy goods vehicles traveling through Switzerland from northern and southern Europe. When the twin tunnel is opened for traffic, it should cut the travel time between Zurich and Milan to 2.5 hours from 3.5 hours, and will provide the key north-south axis link between the ports of Rotterdam and Genoa.

The tunnel will be longer than the Seikan tunnel, which links the Japanese islands of Hokkaido and Honshu. It is the third tunnel to be bored through the Gotthard alpine range following the original rail tunnel, finished in 1880, and the 17-km- (10.5-mile-) long road tunnel completed 100 years later.

The new alpine transit project, or NEAT, is managed by Alp-Transit Gotthard AG. Some of the companies involved in the tunnel construction include Swiss cement maker Holcim Ltd., insulation materials specialist Sika AG, construction conglomerate Implenia AG and German mechanized tunneling technologists Herrenknecht AG.

The volume of road traffic using the alpine transit routes is estimated to double every eight years, reaching around 12.7 Mt (14 million st) in 2009, according to data from the Swiss Federal Office for Transport, while the level of traffic using the alpine rail network has seen little growth in recent years. The new Gotthard and existing Loetschberg railway nodes should increase the freight-carry capacity to 45 Mt/a (50 million stpy) by 2030 from 19 Mt (21 million st) at present. ■

Chairman's column

(Continued from page 2)

nominate, please go to the UCA of SME website (www.uca.smenet.org) and submit your nominations or contact Mary O'Shea at the UCA of SME; phone 303-948-4211; e-mail: oshea@smenet.org. The awards will be given out at the Rapid Excavation and Tunneling Conference in San Francisco in June 2011.

Heather Ivory is the Conference Chair for the 2012 North American Tunneling Conference that will be held in June 2012 in Indianapolis, IN. The first conference committee meeting will be held later this month in Denver, CO.

As I stated in my last column (*T&UC*, Sept. 2010, page 3), the UCA of SME is making some changes in the committee structure in an attempt to make the committees more responsive to the needs of the industry and to be realistic in what a committee of volunteer members can accomplish with the demands from their respective day jobs. We are still looking for members to participate on the Education Committee. The committee will act in an advisory capacity. It will review, consult and provide industry comments and assistance where feasible. The current committee is non-active and, at the request of myself (e-mail: dklug@drklug.com) and Bill Edgerton (e-mail: Edgerton@jacobssf.com), we request that if you are interested in serving on this committee forward an expression of interest complete with your full contact information to either one of us.

Membership dues renewal notices were recently sent out to our current individual, corporate and sustaining members. It is most important that you renew your membership for 2011, as these are the funds required to enable our organization to function. We have added a line on the dues form where you can now make a contribution to the UCA Scholarship Fund. I encourage all members to make a contribution to this fund for 2011. The goal of the UCA Executive Committee is to have a functioning scholarship program that can make multiple scholarships on a yearly basis to assist in educating our young people and thus advance our industry. I would also ask that you request people or companies who are not members of the UCA to join. This is an overall membership responsibility and not just that of Executive Committee members and/or the staff of the SME. We are all on this boat together, so please help row. It will be appreciated.

Please feel free to contact me with any comments or suggestions regarding our organization. ■

George A. Fox Conference returns to New York

The UCA of SME's George A. Fox Conference returns to the Graduate Center City University of New York in Manhattan on Tuesday, Jan. 25 with a full agenda.

As is the case each year, the conference will focus on one aspect of tunneling and underground construction industry. This year, the conference's primary topic is drill-and-blast excavation.

There are five presentations scheduled about drill-and-blast methods with a panel discussion focusing on integrating advances in blasting technology and vibration/crack monitoring to follow. Charles H. Dowding, professor at Northwestern University will moderate the discussion between Andrew F. McKown, president McKown Associates and James P. Lauer, chief inspector - explosives unit, NYC Fire Department. The panel discussion is a new element introduced to the one-day conference this year.

Victor A. Sterner, blast consultant for Austin Powder Co. is scheduled to give the keynote presentation — "Changes in blasting technology."

Among the drill-and-blast projects in Manhattan that are to be discussed during the afternoon session are the East Side Access station caverns and shafts, by Steven J. Maggipinto of Schiavone Construction and the No. 7 Subway extension station cavern by Peter Ayers, director, Arup and Robert Emmert, cavern superintendent for Schiavone.

Steven K. Mergentime, president of MERCO Inc., will conduct a presentation about the Hudson Falls Tunnel Drain Collection System in Hudson Falls, NY and Joel Volterra, associate, Muesser Rutledge and John S. Lizzo, principle geotechnical engineer, port authority of New York and New Jersey, will discuss the rock excavation efforts at the World Trade Center site.

Dean Brox, senior project manager of tunnels for Hatch Mott MacDonald, will wrap up the afternoon session with a presentation titled "Historical and recent performance review of drill-and-blast excavation for tunneling."

As always, there will also be a update on projects in the Northeast U.S. with a special focus on the Second Avenue Subway project with presentations from Alaeden Jlelaty, project manager, Skanska USA Civil Northeast Inc. and Julio C. Martinez, tunnel manager, Schiavone Construction Co.

To register for the conference, contact the SME Meetings Dept., Society for Mining, Metallurgy, and Exploration, Inc., 8307 Shaffer Parkway, Littleton, CO 80127, fax 303-979-3461, e-mail meetings@smenet.org. ■

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BUSINESS PROFILES

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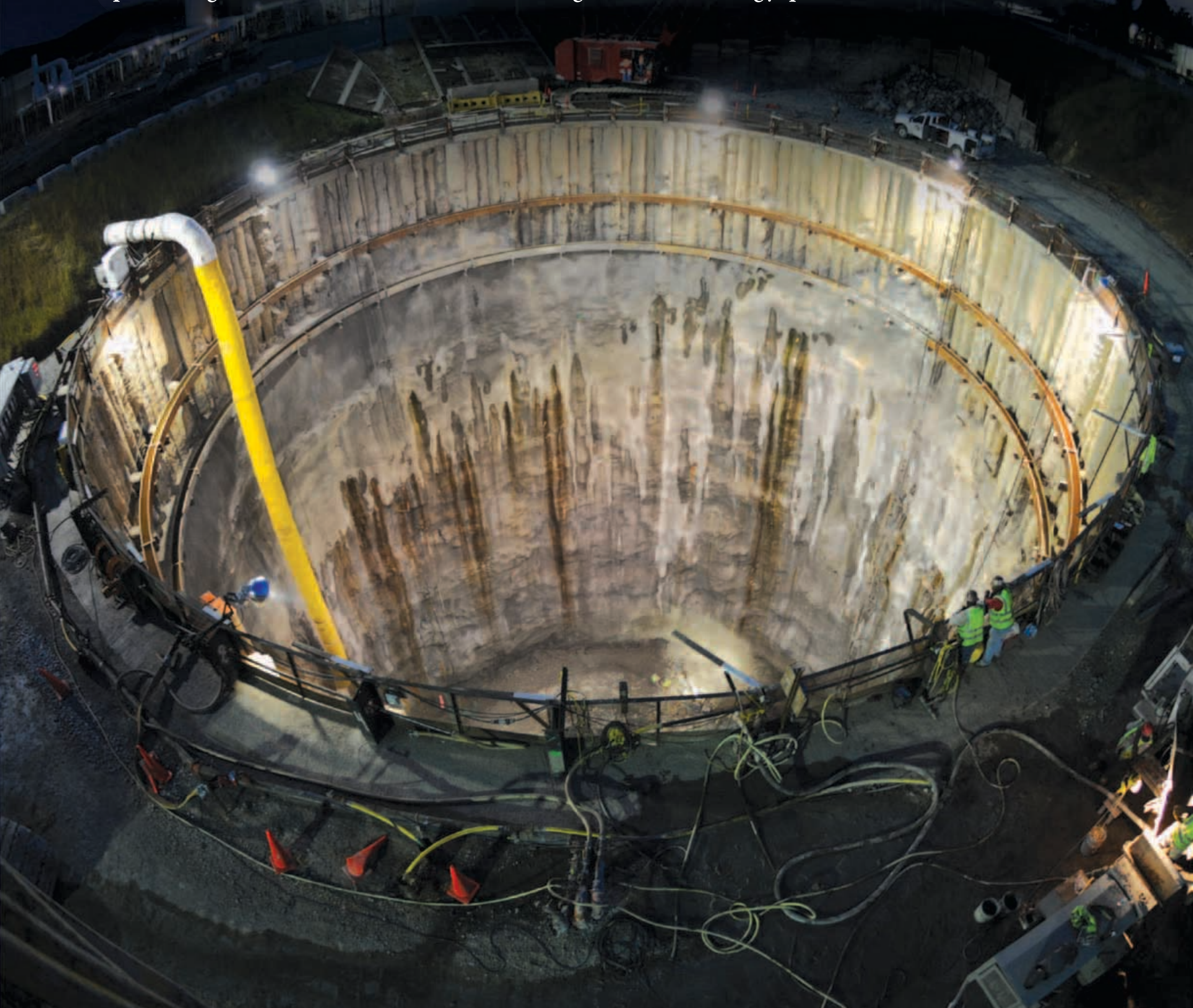

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Jennmar is a multi-national company owned and operated by the Calandra Family. Frank and Jack Calandra are the two common stockholders. In 1972 Frank Calandra shifted Jennmar's focus to manufacturing ground support products for the mining and tunneling industry.

Over the years most of Jennmar's growth has been internally driven. The company currently owns over 80 patents relating to ground support applications. The majority of Jennmar's ten plants have been built exclusively by Jennmar. We maintain eight steel related bolt plants, located throughout the Appalachian, mid-west, and western coal fields. All of them are within two hours of our major customers.

During the late 1990's and into this century, we have been aggressively transplanting our values and technology in the international markets. Currently we have manufacturing facilities in Sturgeon Falls, Ontario; Sydney Australia; Paget, Mackay, Queensland, Australia; and Jining City, Shandong Province, China. Jennmar has two more international expansions coming in 2010 and 2011. This includes, moving from a small, leased space in Sturgeon Falls, Ontario and into our new 50,000 square foot building also located in Sturgeon Falls. Jennmar is also in the process of opening a new facility in Santiago, Chile.

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Tony Calandra – Executive Vice President

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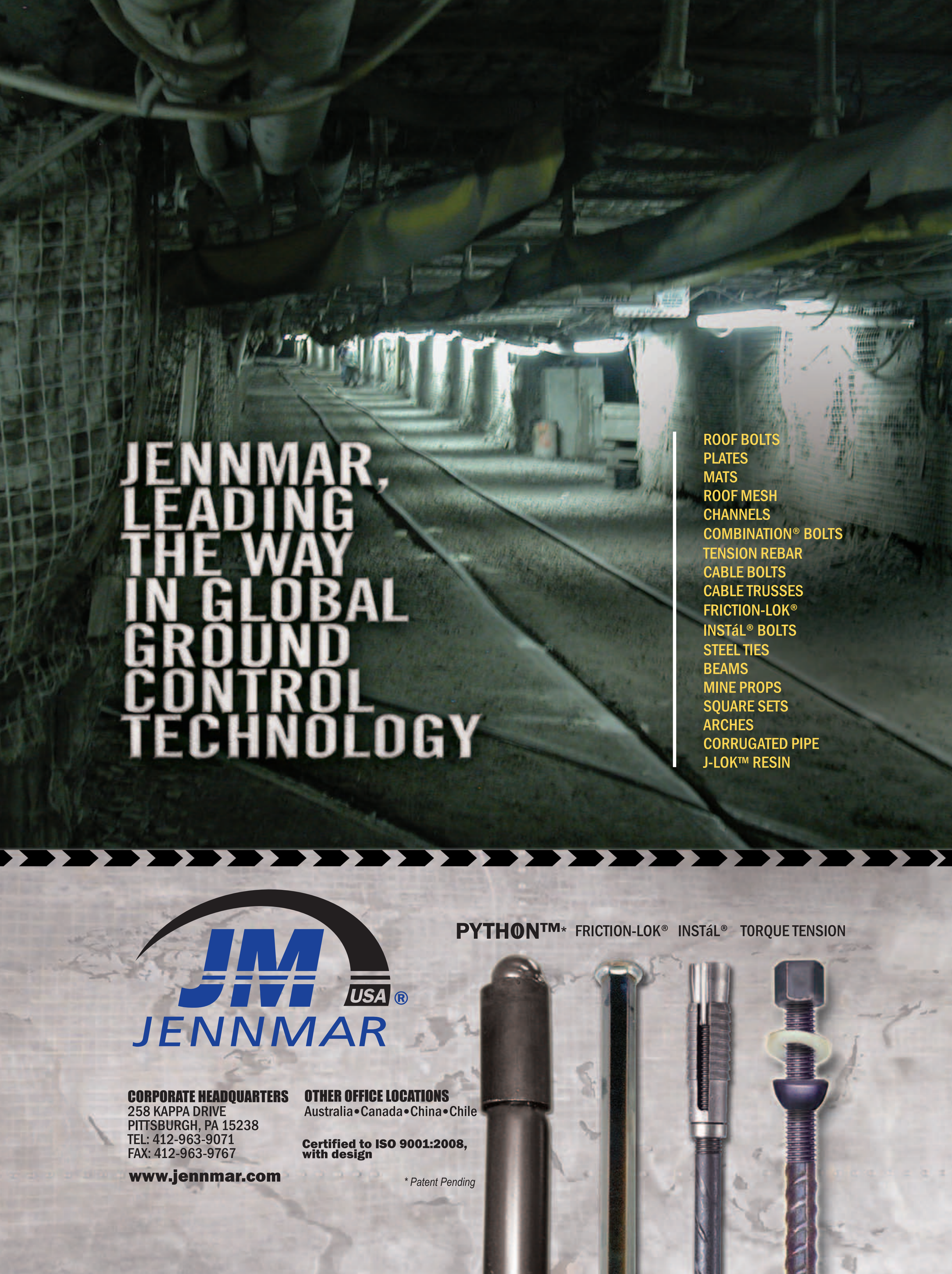
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Messinger Bearings is one of an elite few companies in the world capable of producing large, custom-designed bearings in limited quantities for tunnel boring machines (TBMs). In its new business model, Messinger is addressing the challenge from most end users today about how to get new or repaired bearings of this size delivered in a reasonable timeframe. Customers who purchased 3-row TBM main bearings from competitors just a few years ago took delivery within about eight to nine months. Since then, deliveries have stretched out to 18 to 24 months, or longer. Why the big difference? Many of these manufacturers have shifted their attention to the high volume bearing business and away from small quantity custom applications. Not so with Messinger Bearings.

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 Bearings focuses on providing large diameter custom bearings for unique applications, including those found in much of the TBM equipment. Messinger can now 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 bearings of this size. Messinger's manufacturing facility has recently been expanded to include 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. Given the increased focus for renewable energy, this will likely get worse. Messinger chooses not to participate in the wind energy business because it does not enable the company to support its current customers and its core business, that is, large heavy-duty custom bearings for specialty applications in limited quantities. Aside from new bearings, many of Messinger's customers ask us to repair their existing bearings.

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.

TBM Bearings and More, Planning for the Future

Messinger has recently expanded its capacity to manufacture and repair bearings up to 25-ft OD for TBM and other custom applications. Aside from equipment capacity, additional personnel for engineering and design, metallurgy and manufacturing have been and continue to be added to the team. In addition to the large 3-row and other style cylindrical roller bearings, Messinger is also now well positioned to repair and manufacture new large bore tapered roller bearings.

Messinger Bearings
Telephone: 215-739-6880
www.messingerbearings.com

J.H. Fletcher & Co. – Technology at Work Worldwide

Since 1937, J. H. Fletcher & Co. has affirmed its position as the premier engineering and design firm that creates mobile equipment solutions for underground mines. When rail was recognized as too cumbersome, Fletcher applied rubber-tire technology to underground supply and haulage vehicles. When quicker timbering methods were needed, Fletcher introduced tire-mounted timbering machines. When new methods of roof control were being explored, Fletcher built the first practical roof control drill.

Today, Fletcher remote-controlled and operator-up roof bolters secure overhead rock using advanced computer technology that senses geologic conditions for optimum drilling and roof mapping – without the operator leaving the compartment. Fletcher single- and dual-boom drill jumbos cover headings up to 60′ wide by 35′ high, using high-performance hammers with unsurpassed efficiency, and new Graphic Operator Angle Display technology for greater accuracy. Fletcher scaling vehicles, built from the ground up for the rigors of underground work, remove hazardous materials from heights up to 50′. Fletcher powder loaders allow charging crews to work in lower-than-ever DPM and noise levels. And powerful Fletcher diesel tractors ply in and out of the mines hauling supplies quickly and efficiently.

Features like ergonomically-designed, pressurized operator compartments and demand-based engine speed improve efficiency and operator comfort. Today's Fletcher customers have more options than ever for integrating their overall equipment strategies across machines.

Listen. Think. Create.

Fletcher engineers spend more time in the field, listening to customers telling what they like – and don't like – about mobile equipment. How can operations be made more efficient? How

can operators be kept safer, or more comfortable? Some of our best ideas begin when a customer asks, "Why can't..?" This eagerness to solve customer problems sets Fletcher apart.

Research & Development looks into major ideas that require new designs or application of new technologies. Perhaps a company with more than 70 years in the business has resolved that issue before. In that case, Engineering may be able to apply earlier solutions to modern machines. Either way, Fletcher hires and keeps some of the best electrical, mechanical and hydraulic engineering minds in the business – the same people who will work on your equipment.

Fletcher's unique manufacturing process allows each machine to be assembled by a single team of technicians, following the process from start to finish. It's their handiwork, and every team takes pride in the equipment it ships.

Managing Risk

Every equipment manufacturer and mine should do all it can to optimize the safety and comfort of its workers. No one takes safety more seriously than J. H. Fletcher & Co. Our full-time, fully-staffed Risk Management Department focuses on equipment safety and product liability issues. They support every customer with operator training and re-training programs, audio-visual operating programs, newsletters and safety bulletins, manuals, warning tags -- whatever it takes to help our customers operate profitably, efficiently and with greatest worker safety.

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Kiewit Construction Company

Kiewit is one of North America's largest and most respected construction and engineering organizations. With its roots dating back to 1884, the employee-owned company operates through a network of offices in the United States, Canada and abroad. Kiewit offers construction and engineering services in a variety of markets including transportation, water/wastewater, heavy civil, power, oil, gas and chemical, building and mining. With 2009 revenues of nearly $10 billion, Kiewit's workforce includes approximately 10,000 salaried and hourly staff along with more than 15,900 craft workers.

Kiewit's Underground District has been constructing underground facilities for over 50 years and is recognized as a leader in the tunneling industry with more than 100 underground-related projects ranging from fast-track mining jobs to a $1 billion undersea rail tunnel. Kiewit's underground team incorporates state-of-the-art technology with proven construction methods to ensure excellence and ongoing success. They serve virtually every segment of the construction industry, including projects related to transportation, environmental facilities, water/wastewater/storm water handling and treatment, power, mining and telecommunications.

Kiewit Infrastructure Group
Kiewit Plaza, Suite E-200
Omaha, NE 68131 USA
Telephone: 402-346-8535
www.kiewit.com

A Century of Shotcrete Solutions

Allentown Shotcrete Technology, Inc. is celebrating its 100th anniversary in the sprayed concrete industry.

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 100 years," says Patrick Bridger, President of Allentown. "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 a century."

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 Allentown equipment line has expanded to include a wide range of Gunning Machines, Pre-dampeners, Pumps, Combination Mixer-Pumps, Mixers, Chemical Additive Pumps, Nozzle Carriers, Mortar Machines, Concreting Machines and parts and accessories.

Throughout the years, Allentown has experienced numerous milestones, which have strengthened its position in the market. To find out more about these milestones and Allentown's century of experience, visit www.allentownshotcrete.com or call (800) 553-3414.

Allentown Shotcrete Technology, Inc.
www.allentownshotcrete.com

Robbins Revolutionizes Soft Ground Tunneling

The Robbins Company, the world's foremost supplier of advanced, underground construction equipment, is now offering soft ground TBMs worldwide. Robbins Earth Pressure Balance Machines (EPB TBMs) are now making swift headway on a dozen projects in multiple countries. Although known in the industry for its hard rock machines, innovative machine designs are expanding the company's product offerings to now include machines for mixed ground and soft soils at high pressures.

Over 50 years of Experience

In 1952, James S. Robbins developed the first rock tunnel boring machine in South Dakota, after witnessing the relatively slow rates achieved by a prototype drilling and blasting machine. Subsequent TBM designs, at the Humber River Project in 1954, saw the first use of rolling disc cutters—the discs effectively excavated limestone up to 200 MPa (29,000 psi) UCS.

From those inventive beginnings, The Robbins Company has grown into an international supplier of underground equipment, with foundations in the soft ground, hard rock, and trenchless construction markets. Today, 12 offices and 22 representatives are located in 28 countries around the world, with many local offices providing comprehensive support on regional projects.

Rapid Excavation

Throughout 2009 Robbins Earth Pressure Balance Machines have exceeded project requirements, achieving dozens of project records. In the U.S., a 4.25 m (13.9 ft) diameter EPB is boring the Upper Northwest Interceptor Sewer in Sacramento, CA, has realized rates of 210 m (690 ft) during multiple weeks, all while simultaneously erecting a PVC-embedded concrete liner never before used in North America.

Overseas, two 6.3 m (20.7 ft) diameter Robbins EPBs boring China's Guangzhou metro set an astounding 16 project records in some of the country's most challenging geologic conditions. The machines set records of up to 377 m (1,235 ft) per month in silt, sand, highly weathered granite, and hard rock—rates higher than any of the other 16 machines boring on the project.

In 2010, Robbins will launch three 8.9 m (29.3 ft) diameter EPB TBMs for Mexico's largest infrastructure project—the 63 km (39 mile) long Emisor Oriente waste water tunnel. The tunnel will add much needed capacity to Mexico City's aging and deteriorated sewage system.

A fourth 10.2 m (33.5 ft) diameter machine will excavate a new metro line through the heart of Mexico City after its assembly at the jobsite. Onsite First Time Assembly (OFTA) is a process developed by Robbins to save both time and money to the contractor. By initially assembling the machine onsite, rather than in a manufacturing facility, shipping costs and man-hours required for disassembly are eliminated. The results often yield an assembly schedule several months shorter and high dollars in savings.

Robbins innovations will continue to advance in 2010, with major EPB projects planned for launch in the Dominican Republic, Azerbaijan, India, and China. For more information on recent tunneling and groundbreaking R&D, visit www.TheRobbinsCompany.com or call +1 440 248 3303.

The Robbins Company
Telephone:440-248-3303
www.therobbinscompany.com

CDM – Global Solutions Since 1947

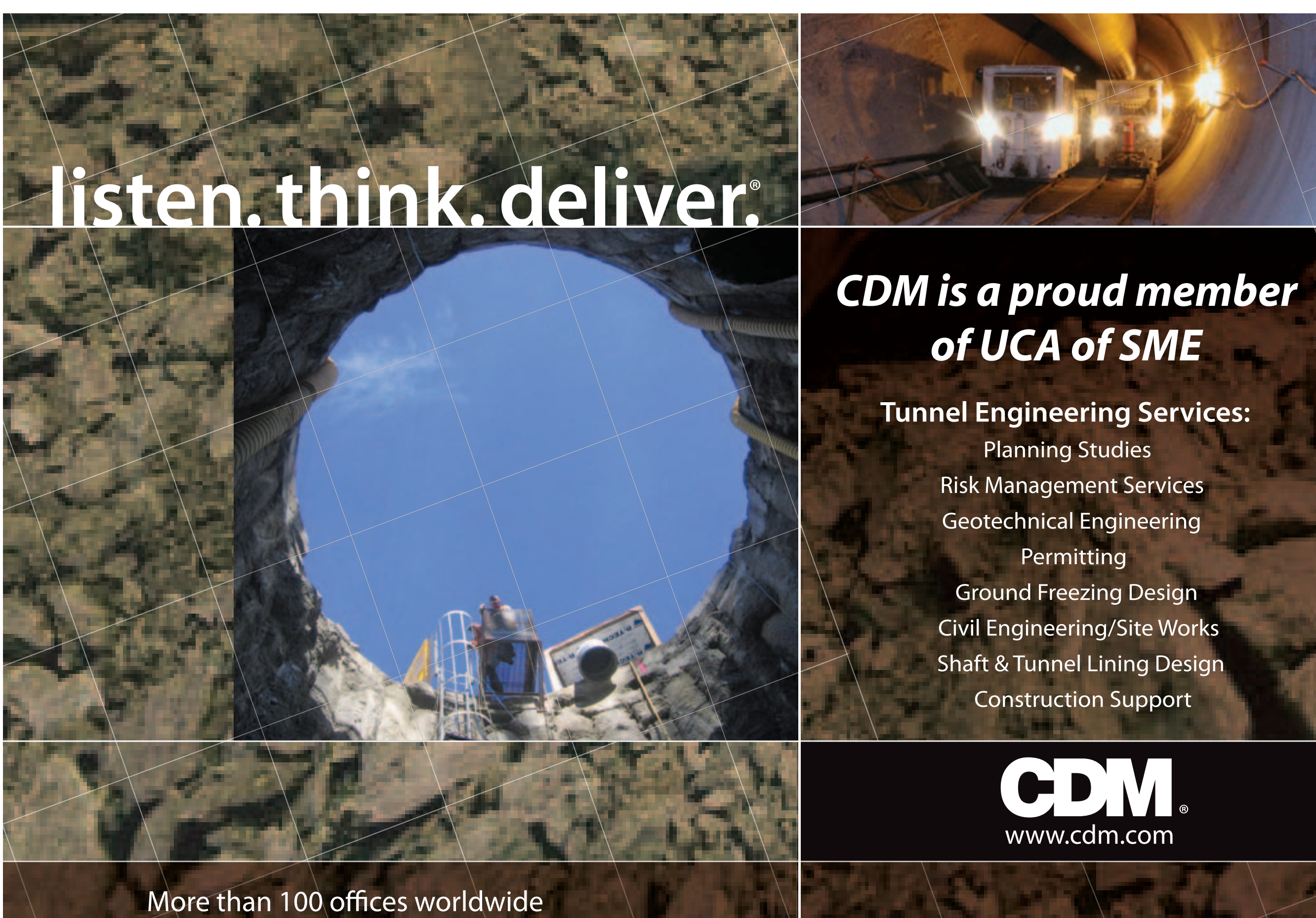
CDM is a global full-service consulting, engineering, construction and operations firm founded in 1947. With more than 4,500 professionals in 110 offices worldwide, CDM maintains a global network of offices and affiliations.

CDM'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'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

CDM
www.cdm.com



URS Tunneling - From Conventional to Innovative

URS focus on your project and project goals, helping you choosing the Right Approach when committing your resources to infrastructure construction, and making the best choices considering:

- Geology
- Best construction technologies
- Risk management
- Equipment selection
- End use

Our strengths are our diversity of experience and depth of resources: from microtunneling to 40′ diameter transportation, water and CSO tunnels, to large hydropower caverns and nuclear waste repositories; and multiple tunnel mass transit projects. From 70,000 psi rock to "zero blow count" saturated river silts, to highly variable glacial tills.

Our emphasis is on developing solutions that are thorough, practical, and cost-effective.

Our Tunnel Design and Construction Services include:

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Facility Types

- Pressure and Gravity Water Conveyance Tunnels
- Gravity Sewer Interceptors and Force Mains
- Roadway Tunnels
- Mass Transit and Rail Tunnels
- Utility Tunnels
- Gas and Petroleum Pipeline Tunnels
- Underground Mines
- Transit Chambers and Underground Powerhouse Structures

Services

Planning and Feasibility

- Identification of System Requirements
- Systems and Fire/Life Safety
- Horizontal and Vertical Alignment Analysis
- Tunnel Construction Method Evaluation
- TBM Evaluation
- Site Investigation
- Soil and Rock Engineering
- Preparation of Geotechnical Reports

Design and Construction

- Preliminary and Final Design Reports
- Plans, Specifications, and Cost Estimates
- Pre-qualification, Bid and Award Phase Assistance
- Construction Phase Services / CM
- Dispute Avoidance and Claims Resolution
- Risk Management Evaluations

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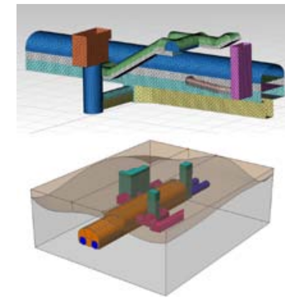
MidaSoft – Next Generation Solutions

Midas GTS is a 3D finite element geotechnical and tunnel analysis software program fully integrated with CAD, auto-meshers, solver and post-processing. Midas GTS handles geotechnical engineering applications, that include tunneling, mining, foundations, excavations, slope stability, soil-structure interaction, settlement, seepage (groundwater flow), consolidation, vibration and seismic analyses.

Midas GTS offers an intuitive GUI that enables the user to create complex geometry in the smallest number of steps based on CAD formats. Different structural and ground elements in conjunction with super pile elements can be incorporated in one model file. Moreover, there are various types of interface elements, which enable the user to simulate soil-structure interaction regardless of the complexity of geometry and interface positions.

All types of T-type and Y-type interconnections, curved tunnels, shaft-lateral-main tunnel connections and tunnel entrances, as well as subway stations can be easily modeled in detail. A special feature exists for defining automated and realistic construction stages for sequential activation and deactivation of excavation segments, structural parts, loads and boundary conditions.



Also, 3D excavation in real time construction sequence including a dewatering procedure may be simulated, and structural support systems including anchors and diaphragm walls may be generated automatically.

The newest version incorporates the robust and advanced DIANA kernel, which supports 64-bit OS & multi-core parallel processing. The solver has been used for over 30 years and proven to be reliable in all research and industrial fields solving complex nonlinear problems.

Midas GTS is a new generation finite element software tool for those who face complex geo-structural projects in urban environments. MIDAS operates and provides technical support worldwide.

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Telephone: 212-835-1666
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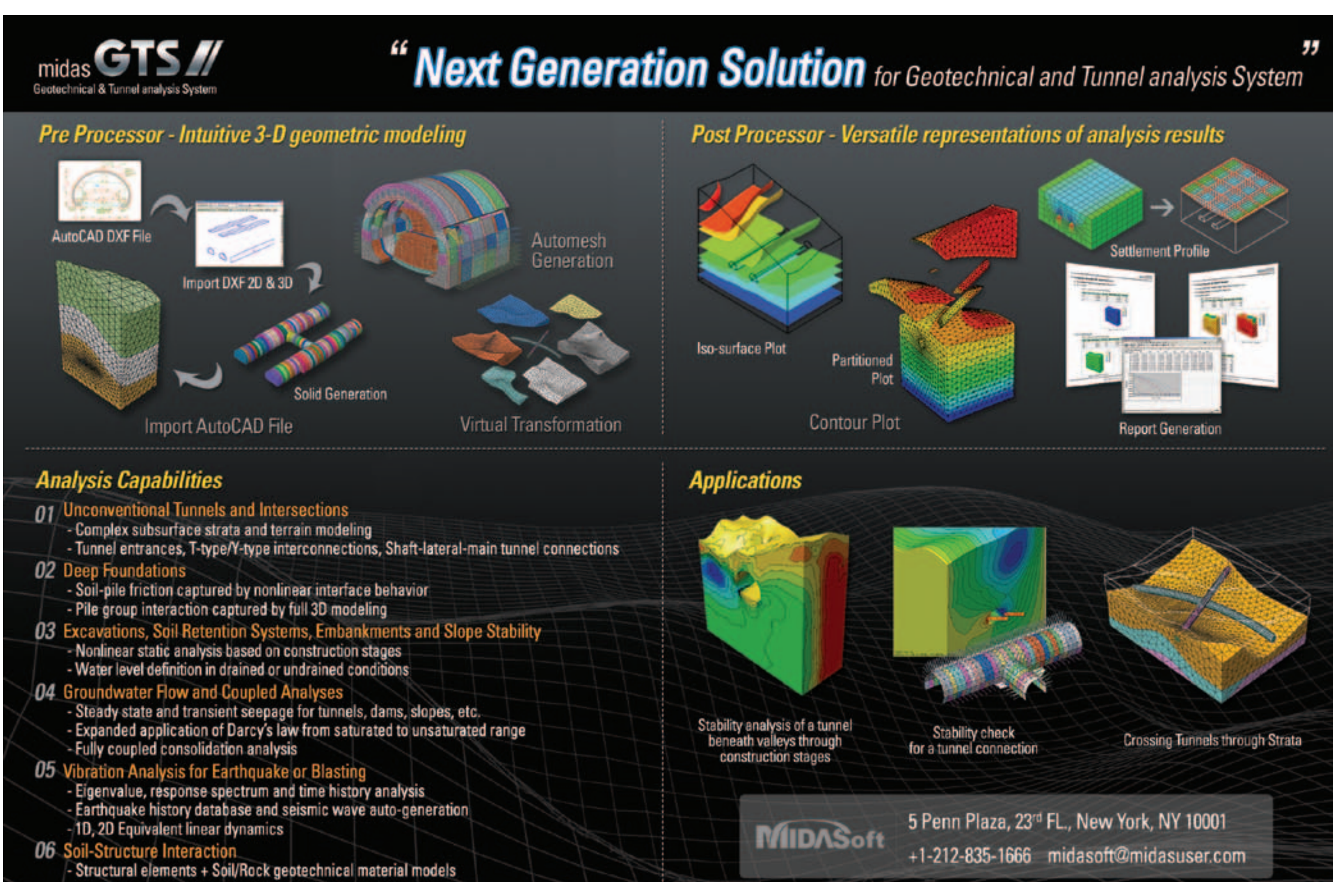

Normet in North America - Equipment and Construction Chemicals for Tunneling and Mining

Normet produces solutions for demanding customer processes in underground mining and tunnelling.

For over 40 years we have developed, manufactured and marketed equipment and vehicles for underground applications. In addition, we provide a comprehensive range of Life Time Care services e.g. maintenance, service programs, spare parts and training around the equipment and the processes they are used for. With over 7500 delivered machines we have became one of the market leaders in our product areas.

One of Normet's key missions is to improve the safety and efficiency of workers underground, through solutions targeted to the work processes of:

- Concrete Spraying and Transport
- Explosive Charging
- Lifting and Installation
- Underground Logistics
- Scaling

Normet offers also a comprehensive range of constructions chemicals for underground mining and tunnelling processes. We distribute the TAM line of products, developed by our partner Tam International.

In North America, Normet is headquartered in Union Grove, WI, USA (Normet Americas, Inc.), and operates in Canada from our new location in Sudbury, ON (Normet Canada, Ltd.) We have sales and field service professionals in a number of locations across the continent, and operate a comprehensive parts management program with stocking in various locations to ensure an efficient means of distribution to our customers.

We are supported by our global head office in Finland (Normet Line Production, R&D and Group functions), Semmco Line Production in Santiago de Chile, and Sales, Marketing and Product Offering Development are headed from Switzerland. With global customer satisfaction in focus, we now employ over 540 business professionals in 23 locations worldwide.

Normet understands not only the equipment we manufacture and the chemicals we supply but the rigors of the customers' underground processes for which they are designed.

Normet Americas, Inc
PO Box 64, 19116 Spring St.
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www.normet.fi

Bradshaw Offers Innovative Tunnel Engineering and Construction Technology

Bradshaw Construction Corporation is a leading contractor in the tunneling industry. With over four decades of experience, we've earned respect as technological innovators through the construction of highly difficult tunneling projects. We owe that success to our commitment to excellence, craftsmanship, safety, and earning our clients' trust.

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."

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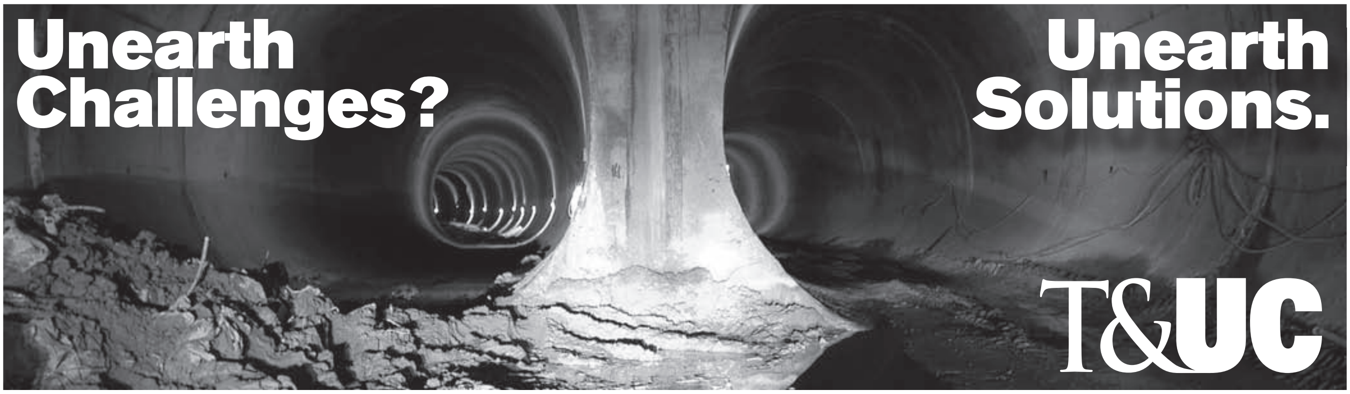

There's More to Moretrench

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; ground freezing; grouting systems; cut-off and containment systems; earth retention and excavation support systems; underpinning and foundation support; deep foundations; 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, Florida, Massachusetts, Pennsylvania, Delaware and Washington D.C. Moretrench is a USGBC member which oversees the LEED program.

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www.moretrench.com

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.

David R. Klug & Associates, Inc.
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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 Corporation, 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 a full line of products including steel and synthetic fibers, rock bolts and anchors and products for shoring and leveling as well.

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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

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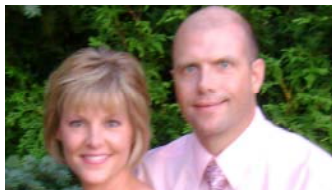

Kelley Engineered Equipment, LLC was founded in 2007 by Brian and Cindy Kelley. Brian, has extensive experience in tunneling and mining equipment design, with 7 years of experience at Robbins, and 13 years at Kiewit Underground Division. Brian is a licensed Mechanical PE in Nebraska, New York, and Washington State. The company has several standard products, such as cable reelers, premium quality rail trucks, skip boxes, and diesel power packs. In addition, Brian leads the design efforts for a broad range of custom equipment, including lifting systems, gantries, pipe carriers, trailing gear, custom attachments, conveyors, heavy load moving equipment, equipment modifications, personnel access systems, and more. KEE partners with select shops, or customers can choose the manufacturer.

Kelley Engineered Equipment, LLC
1210 Beaver Lake Blvd.
Plattsmouth, NE 68048
Telephone: 402-267-0143
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ALPINE Cutters with a Bite

Founded in 1968, Alpine Equipment Corp. is North America's oldest and most experienced manufacturer of roadheaders, especially the Multi-Tool-Miner and those for the NATM, rock and concrete grinder attachments, cutter buckets, scalers, mixers, and shaft sinkers. Willy Kogelmann, Alpine's founder and President, holds numerous patents on these cutting machines. Mr. Kogelmann invented the quick-change transverse and inline axial cutter heads for roadheaders. Spur-gear type cutter transmissions, one of Alpine's unique features, are superior to conventional bevel-gear-type transmissions because they excel in hard rock cutting. The novel cutter buckets can be used for concurrent cutting, mucking, crushing, and sizing. Alpine's advanced cutters can excavate rock and minerals at the lowest-possible cost per ton. Alpine's products are backed by the most experienced team in the industry.

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North America's Leader in Geotechnical Construction

However difficult the ground, only Hayward Baker, North America's leading specialty geotechnical construction contractor, has the diversity of ground modification techniques to solve your geotechnical problem. Tunneling services include: Earth Retention, Underpinning, Waterproofing, Bottomseals, Soil Improvement, and Ground Stabilization.

Hayward Baker has worked on hundreds of tunneling projects and has the right tools and experience for yours.

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 handmined 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 up to 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
East Central (ECIS) & North East (NEIS) Interceptor Sewer Tunneling Projects

Extensive tunneling operations for ECIS and NEIS required numerous ground modifications. Hayward Baker provided chemical grouting and microfine cement grouting for four shaft break-ins, five major freeway over-crossings, 27 manhole connections, and six major or sensitive utility crossings as well as for a major siphon structure and hand-mined access shaft, founded in silty soils containing less than 35% fines.

Other ground modification included locating and filling an abandoned water tunnel, and compaction grouting.

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 soilfrac compensation grouting to protect overlying structures. Heave and settlements were monitored by exterior remote robotic total stations and interior wireless tiltmeters.

Metro Gold Line

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-ft long segment of the proposed 20,000-ft long, 12-ft diameter combined sewer tunnel. A total of 40,000-feet of grout holes were drilled to complete the project. Depths of the drill holes were approximately 170-ft from ground surface.

Hayward Baker
Geotechnical Construction
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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.

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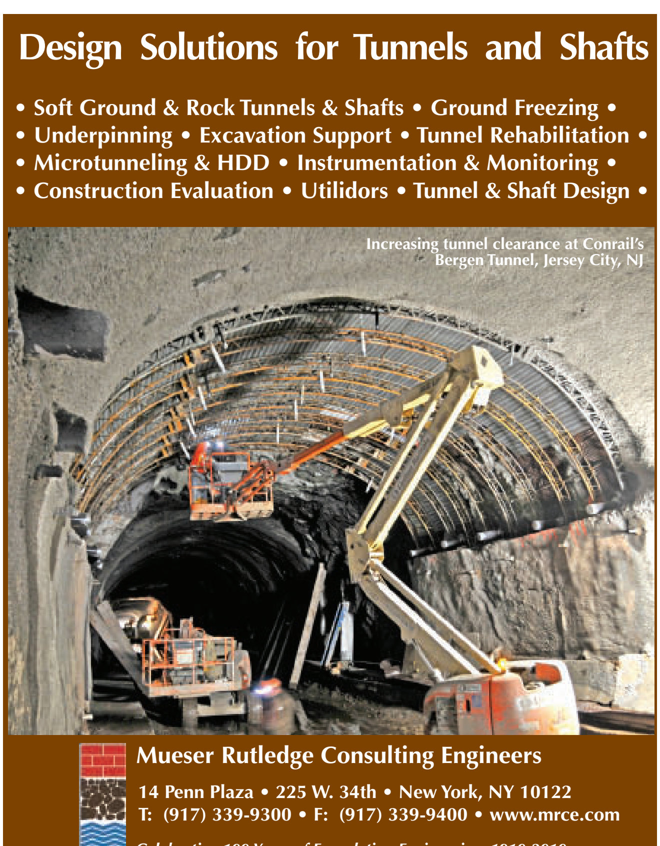
www.stirlinglloyd.com



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Geokon's President, Barrie Sellers, near the loading dock of their new addition.

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North Link Design Underway

Jacobs Associates has been selected by Sound Transit to deliver civil engineering and architectural final design services for the North Link light rail extension in Seattle, Washington. North Link will connect the University Link light rail segment to the Northgate neighborhood via 4.3 miles (6.9 km) of double-track light rail, which consists of 3.2 miles (5.2 km) of twin bored soft-ground tunnels, 1.1 miles (1.7 km) of retained cut fill, and elevated guideway structures. The extension includes two underground transit stations (Brooklyn and Roosevelt), one elevated station (Northgate), a portal structure, and 20 cross passages. With a target completion date of 2020, North Link aims to increase light rail ridership, improve travel time, and add transit capacity in the congested Interstate-5 corridor.

Jacobs Associates
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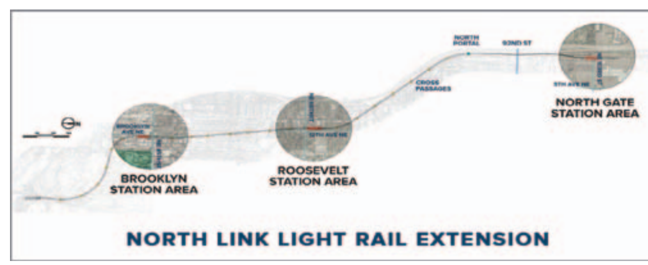

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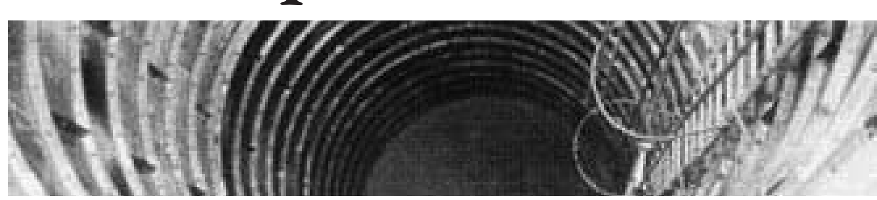


FEATURE ARTICLE

Integration of operations and underground construction: Sound Transit University Link

As part of the Link Light Rail project in Seattle, WA, work was completed at the Pine Street Stub Tunnel (PSST) in early 2007 for the Central Link project. This tunnel was excavated using cut-and-cover construction within the limits of Pine Street. The stub tunnel provides a turn back via double crossover for light rail trains running in the Downtown Transit Tunnel (DTT), as well as a connection point for the next phase of the project, the University Link (Fig. 1).

Jet grouting at the Pine Street Stub Station was completed in 2007 as part of the Sound Transit University Link in Seattle, WA.

Designing the new University Link tunnel connection to the existing PSST was a tricky task. The on-site geotechnical conditions, buried obstructions, geometry, requirements for construction and balancing operational considerations and neighborhood stakeholder concerns associated with the recently completed PSST combined to create a uniquely challenging assignment.

Site geotechnical challenges included rubble fill, landslide deposits and possible contaminated soils. Soldier piles and tiebacks in the path of the northbound and southbound running tunnels, an electrical vault, duct bank and a vent shaft partially above the tunnels, in addition to an existing deep sewer above the southbound tunnel, rounded out the buried obstructions that had to be dealt with.

John Sleavin, Peter Raleigh, Samuel Swartz and Phaidra Campbell

John Sleavin, UCA of SME member, is director of civil and structural engineering, Sound Transit, Seattle, Washington. **Peter Raleigh, Samuel Swartz and Phaidra Campbell** are, associate, associate and senior staff engineer, respectively, with Jacobs Associates, Seattle, Washington, e-mail john.sleavin@soundtransit.org.

The geometry of the PSST connection was originally designed for a tunnel alignment toward First Hill. However, during the preliminary engineering design, the alignment was changed to Capitol Hill. The recent history of construction in the area presented a further challenge of making the connection without causing disruption of traffic on Pine Street. Operational considerations within the PSST dictated limited access and work hours impacting the construction stage, where complicated connections to the PSST for waterproofing, electrical, mechanical, temporary ventilation and systems components needed to be made.

Preliminary engineering design

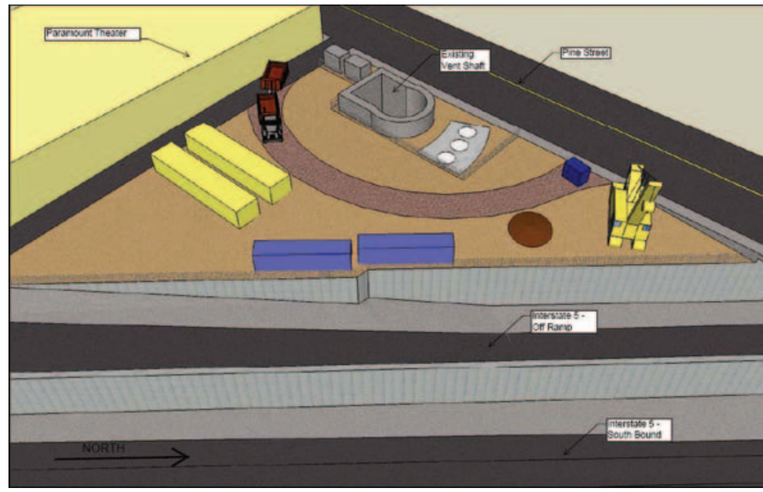
The preliminary engineering concept for the connection shown in Fig. 2 involved the excavation of two tunnel boring machine (TBM) retrieval shafts (one for the southbound tunnel and one for the northbound tunnel), and the construction of tunnels excavated using the sequential excavation method (SEM) between these shafts and the PSST headwall. The proposed short SEM tunnels, which were between 27 and 35 m (90 and 115 ft) in length, would have included the removal of tiebacks and soldier piles that intersect the proposed tunnel alignment adjacent to the PSST headwall.

During final design, an alternative approach was developed that would fulfill the tall order of:

- Reducing the overall costs of the connection.
- Facilitating access to the existing PSST headwall.
- Avoiding excavation of retrieval shafts in close proximity to the existing I-5 freeway.
- Removing the soldier piles and anchors within the tunnel envelope.
- Preparing for TBM excavations up to the face of the PSST headwall.
- Removing the heavily reinforced concrete tunnel "eyes" without undue disturbance to the ongoing transit operations.
- Keeping traffic operation on the street above.

FIG. 1

Conceptual layout of the Pine Street site showing temporary access and adjacent to the PSST ventilation shaft.



Alternative design

A few alternative approaches were originally considered, in addition to the preliminary engineering design. One of the initial ideas was to determine whether any of the TBM breakthrough preparation work could be carried out under the PSST contract that was still under way at the beginning of the University Link design period. This preparation work would have consisted of the removal of the partially exposed soldier piles and part of the anchors that intersect the proposed tunnel alignment from the surface prior to the restoration of Pine Street, as well as removal of the break-out panels in the PSST headwall. However, it was quickly ascertained that this idea would be difficult to implement given the necessity for a very late change to the scope and schedule of the PSST contract, which was near completion at that time.

The alternative was developed as part of the Capitol Hill Tunnel contract (U230) and eliminated the need for any further construction work within Pine Street. This minimized disruption to residences and businesses in the area. This alternative was used in the final design and involved the following activities:

- Ground treatment to facilitate tieback removal through the TBM cutterhead for the southbound tunnel, and stabilizing TBM break-ins for both tunnels.
- Installation of "demising wall" bulkheads within the PSST to facilitate the removal of the northbound and southbound break-out panels and installation of utility connections and light rail operations within an agreed length of the PSST.
- Temporary access/retrieval shaft construction for the northbound tunnel only, taking advantage of the PSST headwall and the existing controlled density fill (CDF) backfill on two of the four shaft sides.
- Access drift from the temporary shaft to a temporary chamber, constructed within the safety of the CDF located between the existing soldier pile wall and the PSST headwall.
- Removal of soldier piles from the temporary chamber and replacement with CDF backfill.
- In-tunnel disassembly of the southbound tunnel TBM.

FIG. 2

Plan view of the preliminary engineering concept shafts and SEM works.

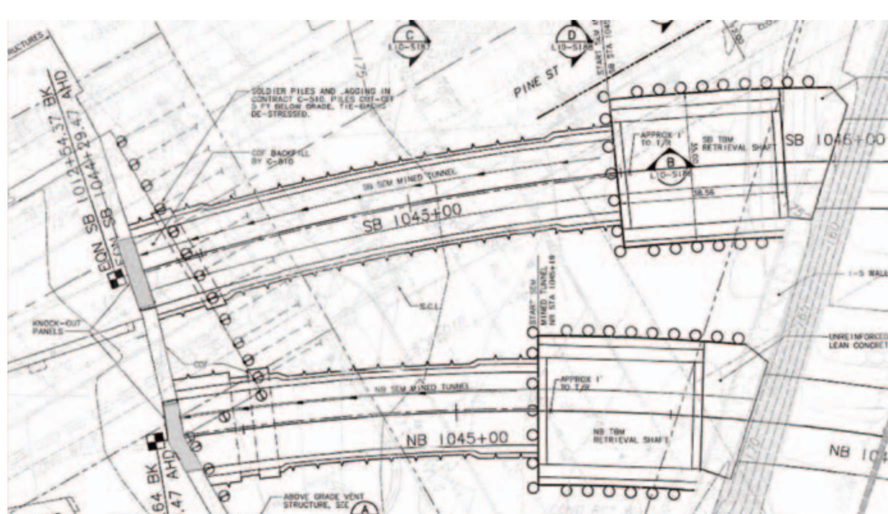
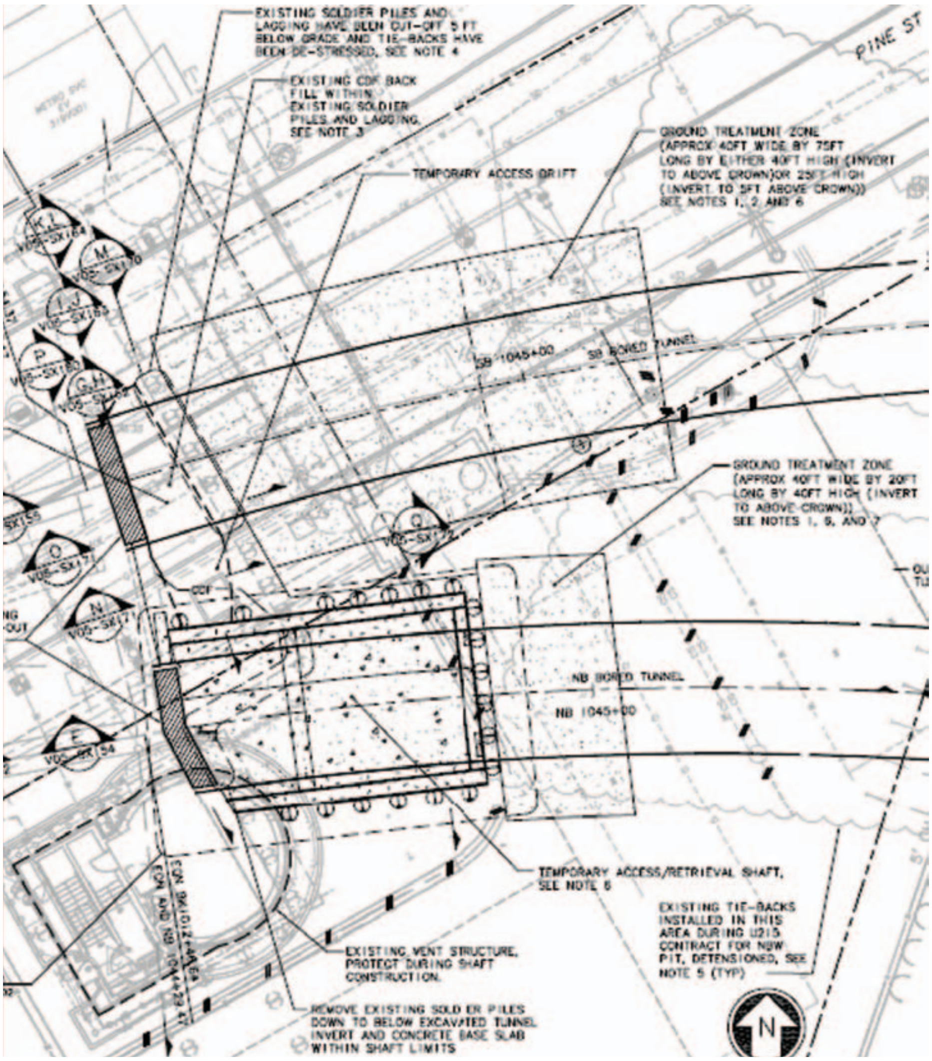


FIG. 3

Plan view showing the adopted final design alternative connection (section arrows provide some idea of the detailed engineering required to make the design work).



- Removal of soldier piles from northbound retrieval shaft.

Figure 3 shows a general layout of the alternative used in the final design.

Ground treatment

Due to the presence of recent alluvium deposits and landslide deposits below the ground water and overlying the overconsolidated glacial soils, a limited ground treatment zone was determined to be required for both tunnels. The ground treatment zones, as shown in Fig. 3, vary for each tunnel. For the northbound tunnel, the zone is large enough to provide a stable face to allow for bottom removal of the east soldier piles, which are used for support of the retrieval shaft and would later be removed from the path of the TBM. For the southbound tunnel, the zone needed to provide a stable face for the east soldier pile removal, but also provide stability for the tunnel heading to allow removal of tiebacks from within the face of the TBM, to be carried out under atmospheric pressure. The southbound tunnel geometry was also dictated by an existing sewer that had to stay in operation throughout the tunnel construction phase.

Ground treatment to stabilize the tunnel crown and improve the soil standup time was designed as jet grouting because of the high silt content of the in situ soils, and used to create a consolidated block of material in the zone of landslide debris between the alluvium and overconsolidated glacial soils. This work had been planned to be carried out from the Sound Transit staging site shown in Fig. 1 next to Pine Street and extend at an angle below the street to prevent further surface disruption and minimize any potential traffic impacts.

Operational considerations, neighborhood stakeholder concerns

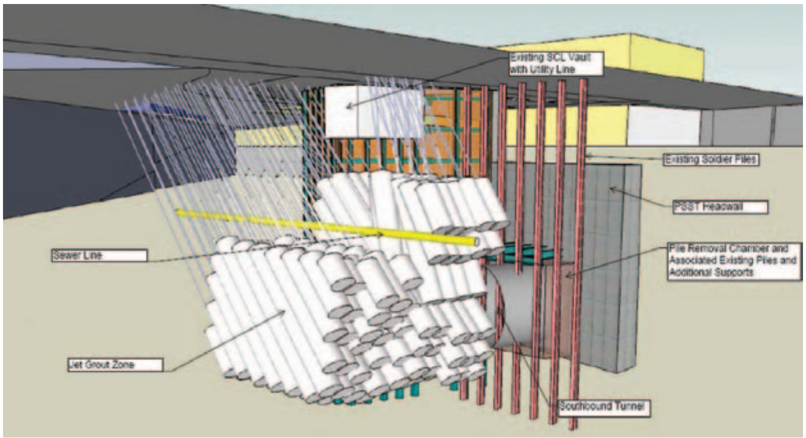
Early in the design of the connection design it was made clear that disruption of the Sound Transit and King County Metro operations within the PSST had to be held to a minimum. After some reflection on all of the construction activity that could not be avoided within the PSST, and the risks this posed to ongoing transit operations, the concept of "demising walls" was developed. The demising walls are fixed bulkheads fitted out with roller and personnel access doors constructed between 15 and 20 m (50 and 65 ft) from the PSST headwall in order to create a construction exclusion work zone. These bulkheads have been designed to prevent the communication of dust and noise from the construction zone, control personnel access into the active transit operations area and maintain the integrity of the existing fire-life-safety (FLS) ventilation. Installation of the bulkheads could not avoid impacts to the PSST.

Relocation of the light rail "bumper posts" reduced the available storage length for light rail vehicles by approximately 18 m (60 ft) and restricted Sound Transit to two-car travel. However, the advantages of the bulkheads outweighed this temporary inconvenience to operations and Sound Transit will not need a three-car service until the completion of University Link in 2016. Once the bulkheads have been installed, they will remain in place until all systems and other finishing works have been carried out, so that the seamless integration of the U-Link with the PSST can be completed.

To address the concerns that site neighbors and other stakeholders would have of further construction being carried out that would disrupt traffic on Pine Street, the design team came up with a feasible approach that would ensure that, for the most part, construction activities would take place within the site boundaries, only stepping outside into the sidewalk areas for very specific operations, such as the angled jet grouting below Pine Street as shown in Fig. 4.

FIG. 4

Jet grouting below Pine St.



Temporary shaft support

Construction of the temporary access/retrieval shaft for the northbound TBM tunnel has been designed to proceed according to the following steps:

- A roughly rectangular shaft will be constructed so that the PSST headwall and additional temporary soldier piles will support the shaft excavation from elevation 52 m (170 ft) to the base of the PSST structure. The layout of the piles avoids the electrical duct bank and the overhang of the existing vent structure.
- The 22-m (70-ft) shaft will rely on the temporary soldier piles, wales at 2.4 to 3.7 m (8 to 12 ft) level intervals, and timber lagging, similar to the successful model used for temporary excavation support of the PSST.
- Temporary soldier piles will be installed in order to safely excavate the shaft to the level of the access drift and provide access for removal of the existing soldier piles within the shaft.
- Upon completion of the works for the temporary pile removal chamber, the shaft will be excavated to a point where the northbound tunnel headwall break-out panel can be removed.
- Existing soldier piles that were used as temporary support for the PSST and are within the temporary access shaft will be removed.
- Once this work has been completed, all of the soldier piles within the tunnel envelope will be cut or extracted after bracing the existing piles in lifts, with removal carried up to 0.6 m (2 ft) above the crown.
- The shaft will then be partially backfilled in lifts corresponding to the pile removal sequence above, with CDF material to allow

FIG. 5

View of shaft showing existing and additional support elements.

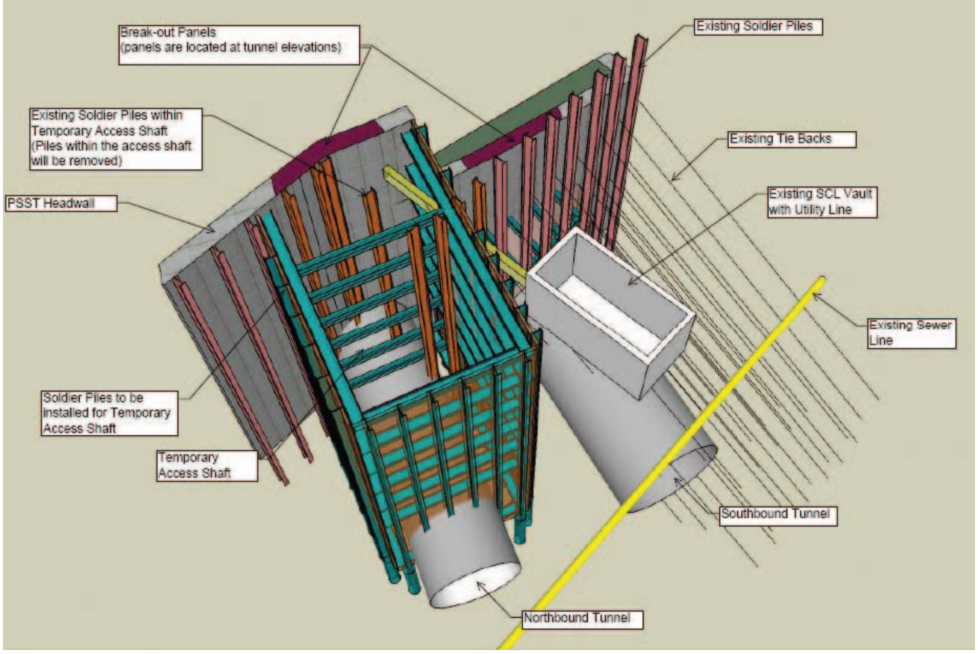
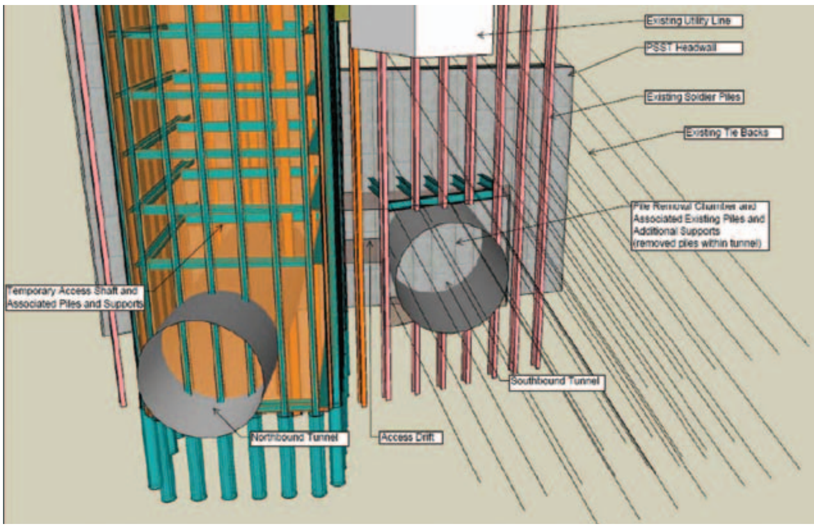


FIG. 6

Transverse section showing access drift and SB pile removal chamber.



for the northbound tunnel TBM to mine into the shaft (Fig. 5).

Access drift and pile removal chamber

To avoid surface disruption to Pine Street, a 3-×3-m (10-×10-ft) access was designed to be driven from the shaft above tunnel axis level within the CDF material between the northbound and southbound tunnels.

This access drift will take advantage of the existing PSST soldier piles on the east side for support. The drift excavation and chamber top bench will be supported by partial steel sets, with lagging or shotcrete to ensure ground stability, placed in line with the existing piles. At this stage, it will be possible for the upper part of the southbound tunnel break-out panel to be exposed and removal of the concrete will begin.

Subsequent benches will be excavated from the top down, exposing the entire break-out panel for removal and the complete length of piles and laggings to be removed from the tunnel envelope.

Beginning from the bottom bench, laggings, piles and 0.9 to 1.2 m (3 to 4 ft) of existing tieback will be removed after stabilizing the soldier piles. The lower portions of the pile removal chamber are expected to be in the overconsolidated Qpgm and Qpgl materials, which are stiff to very stiff clays. The upper portion of the chamber will be within the zone of ground treated soils, which should not become unstable during the short period that they are left unsupported. Figure 6 illustrates a section through the fully developed access drift and pile removal chamber that is larger than required to accommodate the tunnel envelope (southbound tunnel profile shown) because of the presence of tieback anchor points that connect with tiebacks intersecting the tunnel horizon, as well as to allow waterproofing, mechanical, electrical and systems connections to the existing PSST structure. To facilitate TBM excavation, the tiebacks will be disconnected from their associated piles within the pile removal chamber.

Tieback removal through the TBM

During construction of the PSST headwall structure, the temporary excavation support soldier pile wall running northwest was supported by a tieback anchoring system. The tieback system was arranged in five rows at intervals of 3.4 to 3.7 m (10 to 12 ft), which intersect the proposed SB tunnel envelope, as shown in Fig. 6. The tiebacks consist of steel cables anchored over a minimum 4.6 m (15 ft) length at the cable terminus, and intersect the SB tunnels to varying degrees. The TBM is likely to encounter tiebacks over a 13.7-m- (45-ft-) long interval, starting approximately 16.8 m (55 ft) before the PSST headwall.

In accordance with the specification, an earth pressure balance (EPB) TBM will excavate in closed mode (pressurized face) up to this position and then convert to open mode (nonpressurized face) while excavating under the cover of the jet-grouted tieback zone. Following each of the seven- to eight-ring excavation sequences required to mine through the tieback zone, interventions are to be carried out as necessary to cut the cables engaged by the cutterhead or exposed in the face. This is anticipated to ensure that at no time will there be more than 1.5 m (5 ft) of cable exposed that could become entangled in the TBM cutterhead. Stability of the crown during these interventions will be provided by the ground treatment zone. Figure 7 shows a perspective view of the intersection of tiebacks with the SB tunnel envelope.

TBM drives from I-5 to PSST

Once the temporary excavation supports have been removed from the tunnel envelope, both northbound and southbound tunnel TBMs should be able to proceed up to the PSST headwall without difficulty. The northbound TBM will be driven up to the PSST headwall and removed by the temporary access shaft. The cutterhead and shield components will be hoisted out of the shaft and loaded onto a flatbed trailer in easily transportable pieces, to be reassembled at the Capital Hill Station for the southbound tunnel drive.

The southbound TBM will pass through the anchors (as already described) and then through the CDF, aligning roughly perpendicular with the PSST headwall. Once the southbound TBM shield is in position, it will be grouted and the internal elements disassembled, leaving the shield carcass as temporary support for the tunnel.

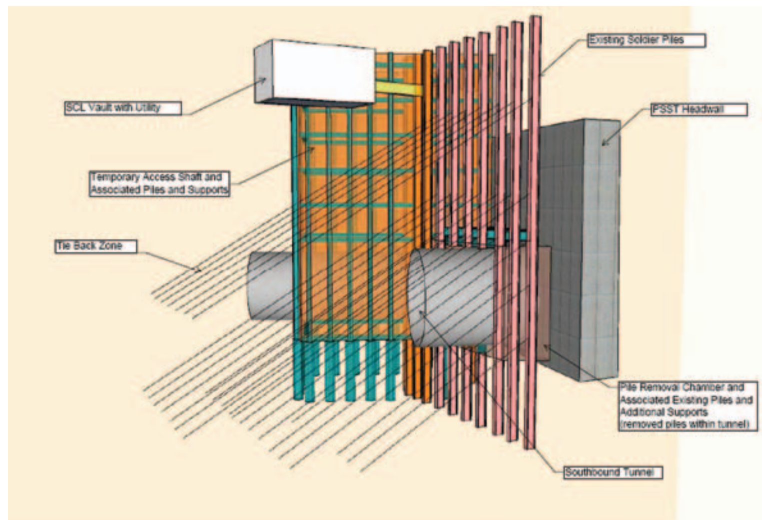
The gap created following removal of the cutterhead between the shield and the PSST headwall will be temporarily supported by bracing around the shield in order to ensure ground stability. The shield diaphragms will be removed, and waterproofing, rebar and concrete or shotcrete will be used to complete the circular cross section of the tunnel up to the PSST headwall. Connections for mechanical, electrical and systems components will be made prior to placing the final lining.

Final lining and connections

After completion of the tunnel drives, the temporary shaft will be left open to allow subsequent contractors to transport materials to tunnel level without requiring access from the existing PSST. As a final step, a cast-in-place concrete lining will be installed to bridge the gap between the precast concrete segmental lining installed in the tunnel and the PSST headwall, including connections for waterproofing, mechanical, electrical and systems components. The shaft will then be backfilled to the ground surface and the existing site restored.

FIG. 7

Perspective of tiebacks intersecting the SB tunnel envelope (ground treatment not shown for clarity).



Lesson learned: Design of the Northlink connection interface

The conditions in and around the PSST were less than ideal for reception of the TBMs and considerable design was required to address the unique challenges of the site. As part of the University Link, both Sound Transit and its designer wanted to think ahead and avoid the difficulties encountered in designing the Pine Street connection. To address this issue, the north end of the University of Washington station (UWS) has been designed to incorporate a reception area and shaft for TBM removal. A number of design elements were incorporated into the north end of UWS to ease future construction. These elements include:

- Access rights have been worked out with the University of Washington to allow for the removal of TBMs from the north end of UWS.
- A TBM retrieval shaft has been built into the permanent works of the north end of the UWS, to allow removal of the TBMs as they mine into the station.
- Fiberglass reinforcing bars have been incorporated into the final design of the headwall at the north end of the UWS, to allow easier removal of the concrete headwall for the TBM break-ins.
- A block of treated ground will be created at the break-in points to the shaft headwall.
- The north headwall was designed to be perpendicular to the direction of the anticipated TBM drives.

Conclusions

The design of the connection of the University Link tunnels to the existing infrastructure at the PSST presented many challenges. Preliminary engineering concepts anticipated retrieval shafts and short tunnels excavated using SEM for this connection, as shown in Fig. 2. However, limited access within the existing PSST structure for the SEM tunnels required an alternative approach. Use of a retrieval shaft adjacent to the existing box structure was designed to accommodate the northbound tunnel, and a short access drift to the southbound tunnel will allow construction to be performed with only limited impact on operations within the existing PSST structure by the use of a demising wall.

This method also limits impacts to adjacent Pine Street; eliminates SEM works; allows tunneling to be performed by TBM for the entire tunnel alignment, which has both schedule and cost advantages; ensures safety and security in the PSST; minimizes interference with existing or ongoing transit operations to reduce risks from safety and contractual points of view; reduces schedule risk by performing preparatory works at PSST prior to the arrival of the TBMs; and gives some additional flexibility for making connections to the existing structure for waterproofing, as well mechanical, electrical, ventilation and systems components.

Finally, the lessons learned from the PSST connection have been directly put to use at the north end of the U-Link project, where UWS ties in with the future running tunnels expansion to the north. Future running tunnels coming into the station will be provided with a TBM retrieval shaft built into the permanent works of the station, greatly reducing the impact of the future expansion on the operations of the University Link light rail. ■

FEATURE ARTICLE

2010 permeation test results for grouts made with ultrafine cement

The 31th annual short course "Grouting Fundamentals and Current Practice" was held at the Colorado School of Mines, in Golden, CO June 7-11, 2010. The field demonstration portion of the course was conducted June 10 at wlh Construction Co.'s yard in Denver, CO.

The full-scale field demonstration presents many types of drilling and grouting equipment in operation as well as numerous grouting methods performed under various field conditions.

As part of the field demonstration, the class was shown the proportioning, mixing, testing and injection of various cement grout mixes into sand columns under controlled and recorded conditions. These sand column demonstrations have been conducted under controlled and measured conditions each year as part of the short course since 1999. The sand column demonstrations were conducted prior to 1999, but with less quality control and minimal record keeping of the proportioning, mixing, testing, injection pressures and the final permeation results.

The goal of the sand column demonstration is to show the students the effect of the water cement ratio and the use of admixture, as well as the fineness of the cement (portland versus ultrafine) used, have on the engineering properties of the grout and the grout's vertical permeation height through the sand.

Test results for the demonstrations conducted in 1999, and for two separate demonstrations conducted in 2000, one at the grout course and one at Geo Denver, were published in the 2001 proceedings of the Rapid Excavation and Tunneling Conference (RETC) (Henn et al., 2001). The test results for the 2002 and the 2003 demonstrations were published in the 2005 proceedings of the RETC (Henn et al., 2005).

Raymond W. Henn and Jacob Prezkuta

Raymond W. Henn, and **Jacob Prezkuta**, members UCA of SME, are senior consultant and engineer, respectively, with Lyman Henn Inc., a division of Brierley Associates, LLC, in Denver, CO, e-mail rhenn@lymanhenn.com or jprezkuta@lymanhenn.com.

FIG. 1

Hany grout plant.

Test results for the demonstration conducted in 2009 were published in the December 2009 issue of *Tunneling & Underground Construction* (*T&UC*) magazine (Henn et al., 2009).

Past demonstrations

The demonstrations over the years have included cement grouts made with various brands of Type I-II portland cements and various brands of ultrafine (microfine) cements. The grouts have been batched with and without admixtures, and the water cement ratios have ranged from approximately 0.7:1 to 4:1.

Beginning in 2000, the injection pressure was set at a maximum of 10 psi (0.7 bar) and held constant during the entire injection period. Previously, the injection pressures ranged from 5 psi (0.3 bar) to 10 psi (0.7 bar). The maximum injection time was, and remains, 20 minutes per column. The sand columns have always been 191 mm (7.5 in.) inside diameter and 1,524 mm (60 in.) tall and are made of a clear plastic. Several different manufacturers and designs of grout plants have been used.

Basic field-testing has always included the grout mix temperatures, specific gravity and marsh funnel viscosity. Several additional field and laboratory test procedures, including cohesion testing, flow cone tests and unconfined compressive strength testing of the cured grouted sand sample, have been performed during several of the previous demonstrations.

More detailed information for a better understanding of the data available and how it compares with the 2010 results presented below is available in the two papers published in RETC proceedings, (Henn et al. 2001 and Henn et al. 2005), and in the 2009 *T&UC* (December, page 28) paper (Henn et al. 2009).

2010 demonstration

The 2010 demonstration consisted of five grout mixes (batches) and five sand columns labeled #1 through #5. There was one mix (#1) of Type I-II portland cement and four mixes made using ultrafine (microfine) cements. Mixes #1 through #4 were mixed using a Hany high shear (colloidal) mixer, mix #5 was mixed using a paddle mixer. Mixes #4 and #5 were identical except #4 was mixed with the high shear mixer and #5 was mixed with the paddle mixer.

Each grout batch was injected into the sand column immediately after mixing and QC testing at the maximum injection pressure of 10 psi (0.7 bar), and the maximum injection time of 20 minutes per column, which remained unchanged from previous demonstrations. Specifics, such as the cement manufacturers, name of the product, water cement ratios and the admixtures used for each mix, are given in Table 1.

Additionally, in the 2010 demonstration, three approximately 41-mm- (1.6-in.-) inside diameter, and 1,181-mm- (46.5-in.-) tall, plastic tubes were each also filled with the same grout mixes used to inject sand columns #2, #3 and #4. There was no sand placed in these three tubes and the grouts were simply poured into the top of the tubes, with each tube being completely filled. The purpose for using the tubes was to demonstrate the shrinkage characteristics of the three grout mixes to the students.

Supervision of the demonstration, as well as quality control, testing and record keeping, were performed by personnel from Lyman Henn, a division of Brierley Associates, LLC of Denver, CO.

FIG. 2

Sand columns (2010) prior to grout injection.

Equipment

A model IC325 Hany Injecto-compact (IC) grout plant was used for the 2010 demonstration. The plant consists of standard components: HCM mixer, HRW agitator and a ZMP grout pump. It is important to note that this is a plunger pump with a maximum output capacity of 51 L/min (13.5 gpm) at a maximum discharge pressure of 1,470 psi (100 bar). The plant is shown in Fig. 1.

FIG. 3

Three plastic tubes used to show shrinkage.

Table 1

Permeation grouting test data summary (June 25, 2010).

Test Number	Supplier	Name of product	(W:C)	Cement lbs (kgs)	Water lbs. (kgs)	Water (L) gallons	Admixture	Mixer	Mixing time (minutes)
T-1	USM Portland	Portland I-II cement	(1.8:1)	47 (21.3)	84 (38.1)	10.1 (38.7)	8 oz DeNeef NS-200 dispersant	Hany high shear mixer	3
Comments: None									
T-2	DeNeef	MC-500 Microfine Cement	(2:1)	55 (24.9)	110 (49.9)	13.2 (50)	7 oz DeNeef NS-200 dispersant	Hany high shear mixer	3
Comments: The column leaked at the bottom of the seal.									
T-3	Nittetsue	Super Fine	(2:1)	88 (39.9)	176 (79.8)	21.1 (79.9)	10 oz Nittetsue mighty 150	Hany high shear mixer	3
Comments: None									
T-4	Minova	Ultracem super	(2:1)	80 (36.3)	160 (72.6)	19.2 (72.6)	None*	Hany high shear mixer	3
Comments: Grout pushed up (jacked) sand column toward the end of the injection, causing the cap to lift up a few inches.									
T-5	Minova	Ultracem	(2:1)	80 (36.3)	160 (72.6)	19.2 (72.6)	None*	ChemGrout 550 pneumatic paddle mixer	5
Comments: Grout pushed up (jacked) sand column toward the end of the injection, causing the cap to lift up a few inches.									

The Hany IC325 plant was used to batch and inject grouts into sand columns #1 through #4. At the request of one of the ultrafine cement suppliers (Minova), the paddle mixer from a ChemGrout model CG550 Rugged series grout plant was used to batch the mix used to inject grout into sand column #5. However, after mixing, the grout was transferred into the Hany IC325 plant's agitator, and the Hany plant's plunger pump was used to inject the grout into sand column #5. The ChemGrout paddle mixer was pneumatically powered and had a capacity of approximately 85 L (3 CF).

The sand columns were 191 mm (7.5 in.) inside diameter and 1,524-mm- (60-in.-) tall. These are the same redesigned and newly fabricated columns used for the first time during the 2009 demonstration. Figure 2 shows the five sand columns during the 2010 demonstration just prior to the start of the grout injection. The three additional plastic tubes used to show the shrinkage are shown in Fig. 3.

Inspection, record keeping and testing

Inspection was performed and the results recorded on each batch of grout. The recorded data includes the quantities of cement and water added to the mixer, the quantities and types of admixtures used, the mixing times, injection pressures and the vertical travel distance of the grout in the sand column versus time. In addition to the inspection, three field tests were performed on each batch of grout. These tests were grout temperature, specific gravity and marsh funnel viscosity. The results of the inspection and testing are given in Table 1.

Inspection and testing were also performed on the three plastic tubes that were filled with grout. The amount of shrinkage in each tube was recorded just after the grout reached its initial set. Table 2 gives the consistency of the grout in the tube as gauged by feel (squeezing the tube between fingers). The three tubes were left to set out doors and out of direct sunlight, and shrinkage measurements were taken periodically. The results of the

Ambient air temp F° (C°)	Grout temp F° (C°)	Specific gravity	Unit weight (pcf) and kg/m³	API (13 B-2) Marsh funnel viscosity (sec/946cc)	Duration injecting into column (min)	Injection pressure psi & (bar)	Final grout water height in column in. and (mm)
80 (27)	71 (22)	1.30	81 (1,297.6)	29	4:00	10 (0.7)	57 (1,447.8)
80 (27)	62 (17)	1.24	77.5 (1,241.6)	29	1:36	10 (0.7)	57 (1,447.8)
80 (27)	65 (18)	1.29	80 (1,281.6)	30	2:11	10 (0.7)	57 (1,447.8)
80 (27)	65 (18)	1.26	79 (1,265.6)	29	1:15	10 (0.7)	57 (1,447.8)
80 (27)	70 (21)	1.28	80 (1,281.6)	29	1:17	10 (0.7)	57 (1,447.8)

shrinkage measurements are shown in Table 3.

It was decided during the demonstration that an attempt would be made to obtain a rudimentary (non-compliant with ASTM) compressive strength for grouts #2, #3 and #4 using the samples collected in the plastic tubes, in order to correlate the approximate strength of each ultrafine cement with the particular water cement ratio used. Two samples of the hardened neat ultrafine cement grouts from each tube were prepared and tested for unconfined compressive strength. The samples were prepared at the Earth Mechanics Institute at the Colorado School of Mines, and testing was performed at Lyman Henn's soil and CMT laboratory. Table 4 shows the results of the 29-day unconfined compressive strength testing.

Discussion of test results

All of the mixes used in the 2010 demonstration used a water cement ratio of 3:1 by weight. Additionally, the sand used to fill the sand columns for the 2010 demonstration was the same sand gradation used prior to the 2009 demonstration. The paper presenting the 2009 demonstration test results, published in the December 2009 issue of *T&UC* magazine, talks about these sand gradations in more detail (Henn et al., 2009).

Four cement products were batched in five batches. One batch was made with portland type I-II cement and the remaining four batches were made with ultrafine cements from three different manufactures. One of the ultrafine cement manufacturers, Minova, requested that one batch of its product be mixed with the high shear mixer and one batch be mixed with the paddle mixer. Minova had performed in-house tests to show that grout made with its ultrafine product would behave the same regardless of which mixer type was used. The company wanted to see if the same results could be achieved independently by using equipment and staff provided at the demonstration.

All five batches did well in the sand column grout

Table 2

Consistency of grout in tube.

Date	Time	#2 DeNeff	# 3 Nittesu	#4 Minova
06/12/2010	16:28	Soft	Med. hard	Hard
06/13/2010	14:00	Hard	Med. hard	Hard
06/14/2010	07:07	Hard	Med. hard	Hard
06/14/2010	18:48	Hard	Med. hard	Hard
06/15/2010	07:05	Hard	Hard	Hard

Note: Batch date 06/11/10

Table 3

Results of shrinkage measurements.

	#2 DeNeef	#3 Nittetsu	#4 Minova
Tube height (in.)	46.5	46.5	46.5
Initial grout height (in.)	46.5	46.5	46.5
Final grout height (in.)	35	36.5	32.5
Final bleed height (in.)	11.5	10	14
Percent reduction	24.7%	21.5%	30.1%

Table 4

29-day unconfined compressive strength test results.

Sample	2-1	2-2	3-1	3-2	4-1	4-2
Sample height (in.)	3.161	2.854	3.026	3.04	3.147	3.017
Sample diameter (in.)	1.73	1.604	1.62	1.62	1.595	1.641
Strength (psi)	500[1]	610[1]	2290	2190	2550	1320
Break type[2]	n/a	3[1]	5	3 or 5	2	2

[1] Estimated value; sample had no clear break point because it was too soft.

injection. All grouts made it to the top of the columns well under the prescribed 20 minutes. After reviewing the results of the vertical flow of the grouts' various times from past demonstrations, it was concluded that the methods used to fill and densify the sand used in the columns needed to be evaluated. This is the one operation in the demonstration that has not received as much attention as the grout batching and injection. It was agreed by the sand column demonstration team to address this issue for next year's demonstration.

As previously noted, there was a last minute addition to the 2010 demonstration of three approximately 41 m (1.6 in.) inside diameter and 1,181-mm- (46.5-in.-) tall clear plastic tubes, meant to show grout shrinkage. Several interesting results of these tests were observed. The first was the time required by each to harden. Second, the grout in each tube turned a dark green color and stayed that color for approximately 29 days from the time of casting until compressive strength testing. During preparation of the grout cylinder from the tubes for testing, when the hardened grout cylinders were removed from the plastic tubes, the grout turned from dark green to a gray color. Additionally, from approximately 24 hours after casting until compressive strength testing, the grout in the tubes gave off the "rotten egg" smell of hydrogen sulfide. This smell can be attributed to the high slag content of the mix of the ultrafine cements. The grouts lost approximately one third of their volume to shrinkage when setting, as was expected.

As noted above, the two hardened grout cylinders from each tube were tested for unconfined compressive strength. Grout #2 was very soft and, as a result, didn't break in a normal fashion but failed by compressing as clay would. Because of this, it was difficult to determine when the sample technically "failed" and, therefore, the strength value is only an estimate. The other two grouts performed at strengths that would be expected for ultrafine cements.

We are planning to perform these shrinkage tube demonstrations and testing next year on all five grout batches. ■

Acknowledgments

The authors thank Warren Harrison of wlh Construction Co. for the use of his yard, paddle mixer and other facilities. Thank you to Joe Schatz of ChemGrout for providing the sand columns, grout header and supervising the batching of the grouts. Thanks to Fred Sherrell of Surecrete for supplying the Nittetsu SuperFine cement, to Brian Iske of DeNeef for supplying the MC500 microfine cement and to Joe Burdette of Minova for supplying the Ultracem ultrafine cement. Thank you Bobby Cannon of DSI Underground Systems for providing the Hany IC325 grout plant and to Billy Brown for operating the plant. Thank you Brian Asbury for the use of the EMI equipment. And, as always, a big thank you to Don Hegebarth, independent grouting consultant, for doing all of the preplanning and organizing the overall demonstration. ■

FEATURE ARTICLE

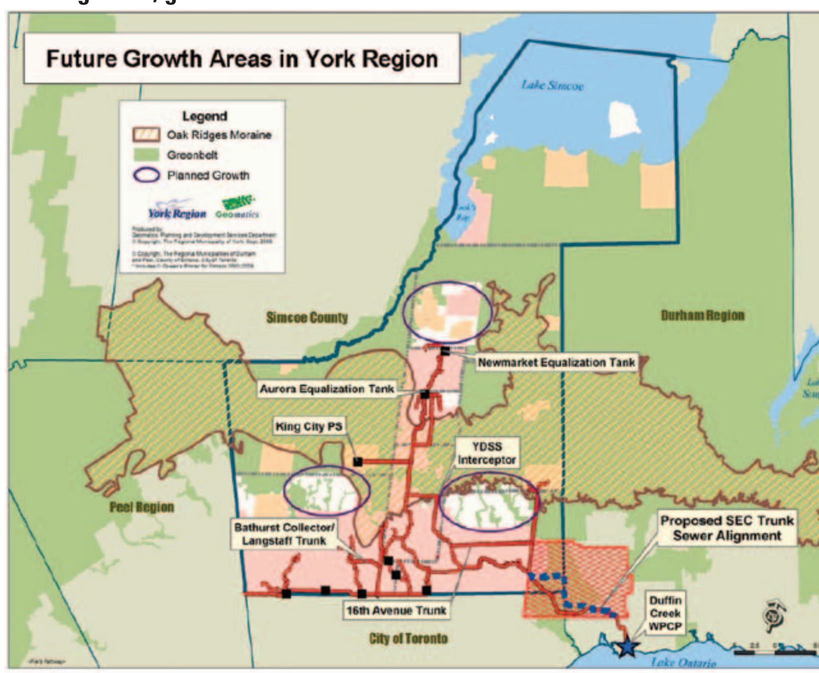
How to deliver your project on time: An owners' procurement strategy

The Regional Municipality of York, located north of the City of Toronto in Ontario, Canada, has experienced unprecedented growth during the past decade, with new home construction averaging 15,000 units per year. This rate of growth is planned to continue well into the future with a projected growth of more than 500,000 new residents by 2031, combined with a target of more than 300,000 new jobs to provide a sustainable economic base for the region. It should be noted that York region has been designated as one of the key growth centers by the province of Ontario, aimed in part to meet the housing and employment needs of Canada's growing population.

York Region is a mix of urban and rural areas and is one of the most desirable areas to live in Southern Ontario. York region offers an attractive lifestyle, with its nine municipalities and the amenities created by the many rivers, streams and protected greenbelt areas that encompass more than 69 per cent of the region's area.

FIG. 1

Future growth, greenbelt and watershed areas.



The existing wastewater system, the York Durham Sewage System, was constructed in the 1970s and is comprised of more than 200 km (124 miles) of large 2.4 to 3 m (7.8 to 9.8 ft) diameter trunk sewers, extending from a water pollution control plant (WPCP) on Lake Ontario to the most northerly community, approximately 80 km (50 miles) from the WPCP (Fig. 1).

Parts of this system, and in particular, a 15-km (9-mile) length of the Southeast Collector Trunk Sewer, will approach its hydraulic capacity within the next few years, thus necessitating a major program of twinning and trunk system expansion to accommodate the servicing needs for the planned future growth in York region.

Growth pressures, combined with the need to protect and sustain York region's many natural and heritage features, are the key challenges for planning and expanding the capacity of the Southeast Collector Trunk Sewer portion of the waste water system. York region has undertaken an extensive individual environmental assessment (IEA) and developed a unique strategy for procuring equipment, materials and labor to meet the challenges of providing new trunk wastewater capacity in a timely manner. The strategy should also protect the many natural and cultural features of the area. A number of strategies are underway to achieve these goals.

Extensive environmental planning

Government approval of the IEA was required prior to construction starting on the capacity expansion of the Southeast Collector Trunk Sewer (Fig. 2). This project is the first large-scale waste water project in Ontario to undergo this level of scrutiny. The study examined a full range of alternative solutions, including an assessment of 13 alternative routes for the trunk sewer expansion, along with an extensive program of public consultation with agencies, stakeholders and property owners. This comprehensive environmental planning study included the collection of baseline data on soils, surface and ground water conditions, as well as data on natural environmental features related to terrestrial and aquatic species of the area. A detailed geotechnical and hydrogeological investigation was carried out at an early stage of the project planning. This thorough knowledge of soil conditions was used to set the sewer profile, alignment and location of drop structures to maintain

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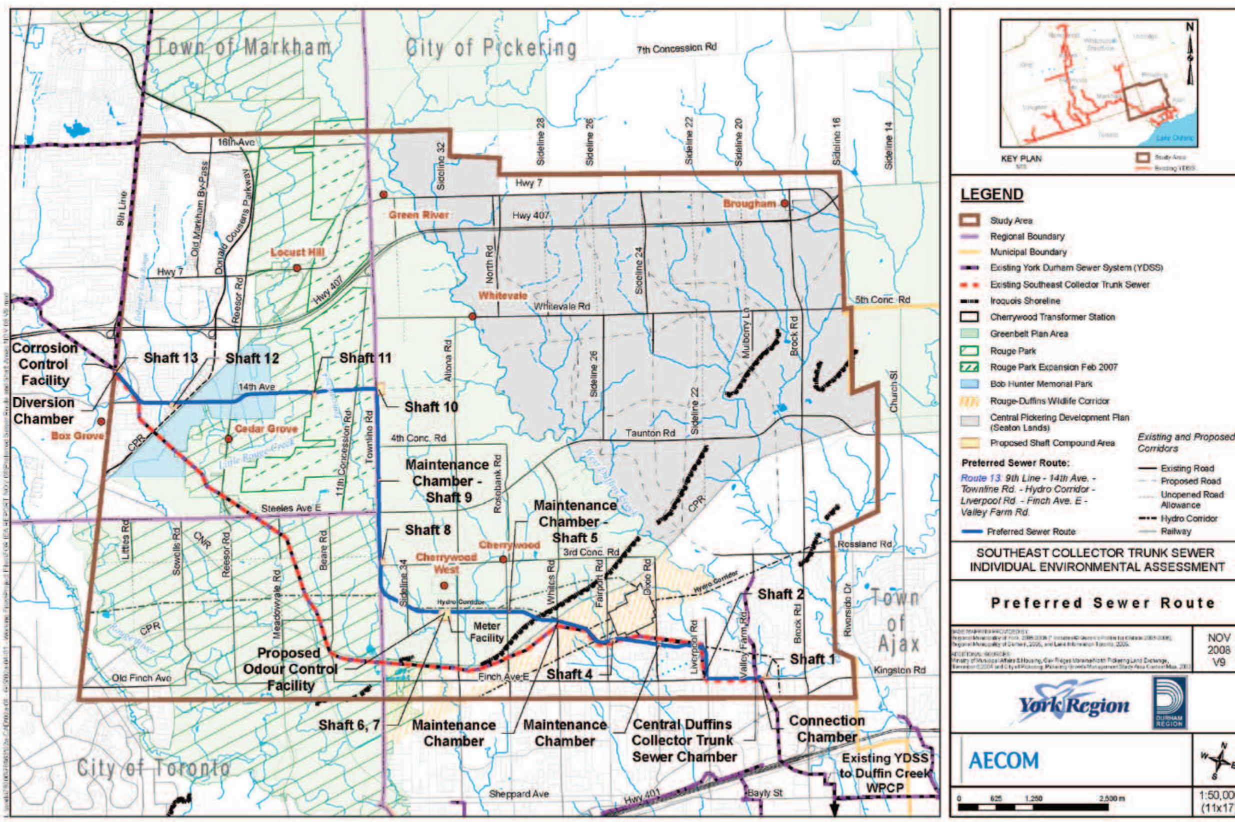
FIG. 2



Southeast collector trunk sewer — preferred sewer route.

the tunneling activity in very competent till material, regionally referred to as the Newmarket Till deposit. This geological database was used for the development of a geological baseline report (GBR) for construction purposes (Fig. 3). Similarly, groundwater pump tests were conducted along the pipe alignment, confirming that minimal dewatering would be required at the construction shaft locations.

The study recommended the use of earth pressure balance tunnel boring machine (EPBM) technology, using a single pass segmental liner system. Further, sealed shaft construction has been recommended for the construction shafts. The study concluded that the use of this equipment and construction methods would ensure a minimal impact on the communities and natural environment along the construction route. This early planning study and community engagement program provided a solid framework for the design, approvals and construction phases of the project.

Advanced procurement of equipment and materials

Procurement of tunnel boring machine (TBM) equipment. York Region pre-purchased four EPBMs from Lovat Inc., with a machine specification to undertake the tunneling activity in the Newmarket Till materials. The Lovat Inc. local office and assembly plant is located in Ontario, Canada, making it a logical choice for York region to use this equipment manufacturer for the four machines.

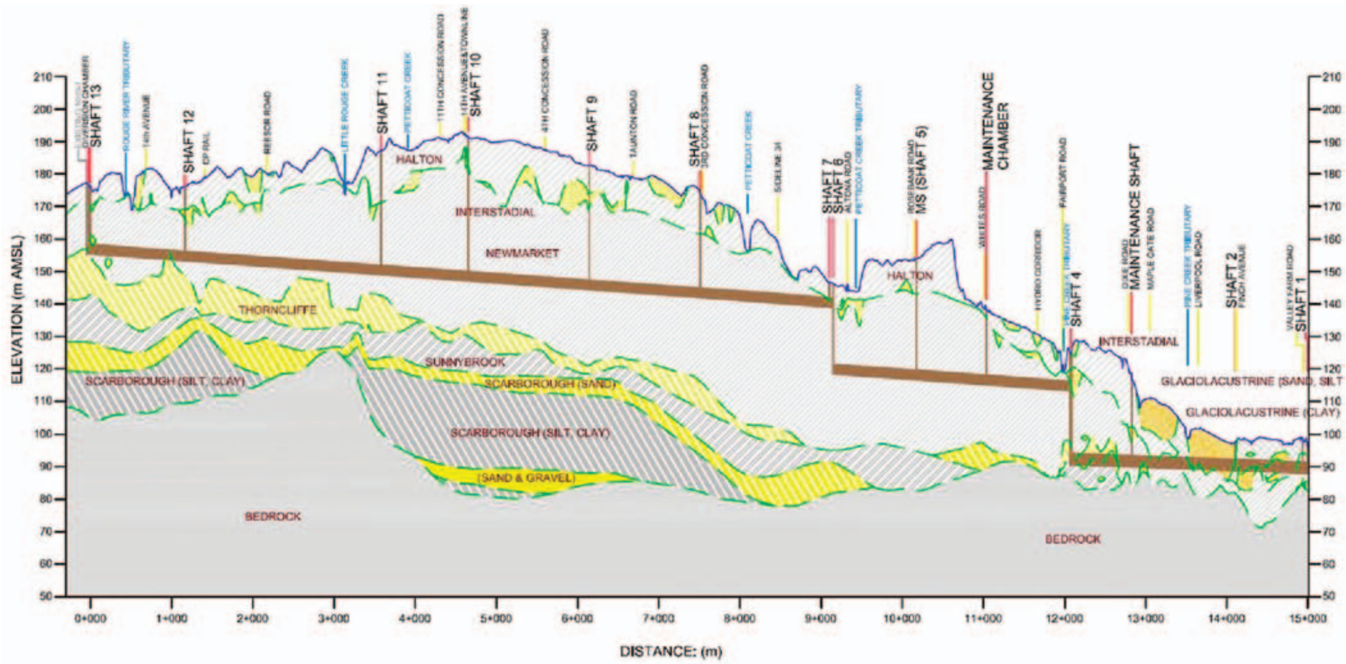
The TBMs are in production and will be available for delivery to the site immediately upon start of construction. This early procurement of equipment by York region will allow the contractor to begin tunneling activity at or about the same time, using all four machines. The total project length of 15 km (9 miles) will be split into approximately equal length segments to allow concurrent tunneling effort by four tunnel crews.

Procurement of segmental liner materials. York Region issued a tender for the supply of segmental liner materials to all four TBMs (Fig. 4).

A supply of up to 400 liner segments will be required on a daily basis to meet the pipe installation progress of the four TBMs. Given this volume, the contract specification for the liner materials required the successful bidder assemble a dedicated plant to maintain this liner supply rate. The liner segments are now in production and will be available for supply to the site immediately upon start of construction.

FIG. 3

Geological profile.



Advancing project funding

York region's commitment to allocate significant funds in advance of government project approval — in order to undertake the purchase of long delivery items such as TBM equipment — is a key aspect of the project. Another key aspect is the establishing of a plant for the delivery of segmental liner materials prior to approval. This advance funding of materials and equipment demonstrated York region's commitment to the successful commissioning of the new Southeast Collector Trunk Sewer on schedule in 2014. It should be noted that the capital cost of this trunk infrastructure is funded through a 'per lot' charge levied against the future developments that will be serviced by the trunk system. In this way, a user-pay principle is maintained and the burden for payment is allocated against the future homeowners benefiting from the expanded waste water system.

Early prequalification of contractors

A prequalification process was completed and four firms were prequalified to bid as the general contractor for the entire project. The contractor prequalification process was an important step in the procurement process to ensure a successful delivery of the project on time, with competent and knowledgeable contractors with appropriate resources. The pre-purchase and assembly of the TBM machines, along with the pre-ordering of the segmental liner system, will ensure an early startup of tunneling activity, thus increasing the tunneling construction time to meet the project delivery date. York region, along with its consulting team and Lovat Inc., developed a detailed TBM specification that will ensure "state-of-the-art" tunneling machines are assembled and delivered to the site on time, as required by the contractor's schedule. Other important design steps included a constructability review early in the design process to incorporate the ideas and suggestions from the construction industry into the design details.

Project marketing

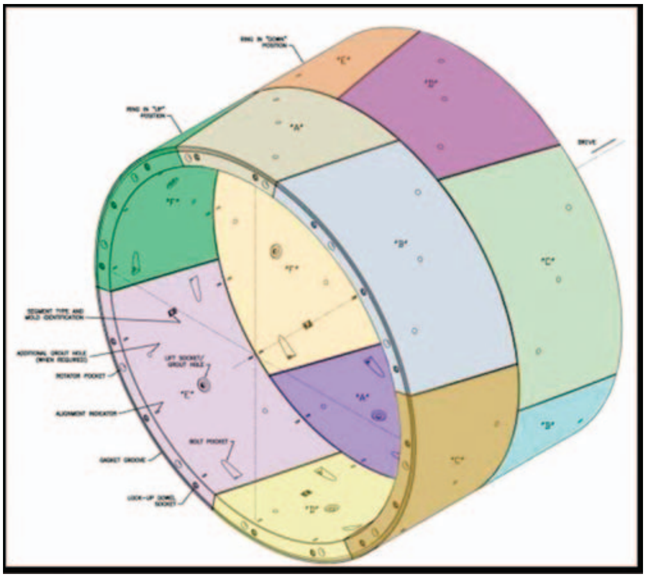
Conventional tendering allows the marketplace to assess the opportunities for tenders based on a number of factors relating to current workload, proximity of work to home base, owner/consultant reputation and early knowledge and awareness of project details. Owners can influence some of these factors by making an effort to inform the construction industry of project details and seeking feedback on design, construction and tendering issues. Workshops, trade journals, conferences and bidders' information packages are all useful techniques to keep the industry informed and prepared for the tender packages when released.

Assessing bidders' risk

One key factor that limits bidders' interest in project tendering may relate to the exclusive transfer of risk to the successful contractor through general conditions clauses, performance bonds, liquidated damages and the absence of dispute resolution methodologies. In certain circumstances, owners may consider some degree of risk sharing clauses to increase bidders' interest in the competitive bidding process.

FIG. 4

Segment shape — trapezoidal.



Preapproval by owner

Schedule certainty can be increased through the early procurement of project approvals and permits. Given that the Southeast Collector Trunk Sewer is time-driven, York region acquired many of the key project approvals, permits and permissions in advance of project tendering. Where appropriate, the conditions of approval will be assigned to the general contractor as part of the contract specifications. This early procurement of permits is a further step in clearing the way for an early construction start and successful completion of the project.

Some of the key project approvals secured in advance of tendering included environmental approvals, local approvals of site plans for compounds and above-ground buildings and structures related to meters and odor control facilities. Further, it is planned that York region will acquire bylaw exemptions for extended construction hours to permit two shifts of tunneling activity.

Advanced site preparation contracts

A number of early works prepared the work sites for the general contractor in advance of the contractor mobilizing tunneling contacts.

Haul road construction

The upgrading of haul roads for spoil removal in advance of the TBM launch and the start of tunnel mining is underway. This proactive improvement of haul roads will reduce impacts from spoil removal on local community residents and will provide a positive legacy for the local communities impacted by the construction activity. Such road improvement will also ensure the uninterrupted access of heavy loads relating to construction equipment and segmental liner delivery.

Securing of spoils disposal site

Several options were considered to secure a satisfactory spoil site or sites for the approximate 20,000 m^3 (706,000 cu ft) of spoils material. Spoils sites selected in advance of the tunneling activity ensure that all local and environmental approvals are in place for site filling, allowing for continuous and uninterrupted haulage of spoils from the construction shaft locations. Alternative sites will be considered based on the net benefit that can be realized from clean fill to enhance communities or improve areas for alternative land use opportunities.

Property acquisition

York region formalized the acquisition of all property needs, including purchases, property access rights as well as temporary and permanent easements in advance of contract awards. Any conditions resulting from property access agreements were transferred, where appropriate, into tender documents for compliance by the contractor. The early resolution of property issues for the use of lands for construction compounds, shafts, material and spoils storage will ensure the uninterrupted progress of construction activity, particularly where private lands are involved.

Local utility relocation

The size of construction launch shafts, particularly within developed areas along the sewer alignment, will necessitate the relocation of local utilities to accommodate 10- to 12-m- (33- to 39-ft-) diameter construction shafts. The relocation of local utilities will be done in advance of the general contractor's site mobilization. This early work clears the way for an early and continuous mining operation.

First Nation clearance of compound areas

As many as 13 First Nations communities have inhabited the planned work site areas over a 300-year period leading up to the early 1800s. Past cultural and burial sites are unrecorded and can only be determined through on-site stripping of top soil and involvement of First Nations communities and archaeologists. This type of advanced contract work was carried out to clear the compound and shaft locations of any such cultural artifacts and confirm no evidence of burial sites, thus ensuring uninterrupted construction.

Conclusions

The need for additional sanitary servicing capacity by a firm date of 2014 to allow the continued development of residential, commercial and industrial growth in York Region has necessitated an owner-initiated procurement of materials and equipment, including a number of site preparation contracts, all aimed at ensuring final delivery of increased sewer capacity on schedule. York region's risk of undertaking expenditures of up to 30 per cent of the project capital cost in advance of the project approvals and general contract awards is offset by the increased certainty of delivering the project schedule on time. ■

FEATURE ARTICLE

Robbins tunnel boring machines embark on projects around the world

From some of the largest tunnel projects in the some of the most vibrant cities, to smaller projects in remote corners of the globe, the Robbins Co. announced two tunneling projects in which its tunnel boring machines will be used.

Robbins earth pressure balance (EPB) machines undercut Downtown Zhengzhou. Zhengzhou, a city of 7 million people, is set to become a crossroads for rail commerce in China. The country's future main routes, traveling between Beijing and Guangzhou (North-South), and between Xuzhou and Lanzhou (East-West), will intersect in the city. The plan includes up to four rail lines in Zhengzhou itself, which will eventually link up to the national lines. Excavation of Zhengzhou Metro's new Line 1 tunnels began on Sept. 28, 2010, when the first of two 6.3-m (20.7-ft) diameter Robbins earth pressure balance (EPB) machines was launched from a 16-m- (52-ft-) deep shaft.

The second machine was scheduled for a launch in late October. Both tunnel boring machines (TBM) for the 11th Bureau of the China Railway Construction Corp. (CRCC) will excavate under downtown Zhengzhou with cover as low as 8 m (26 ft). The parallel 3.6-km- (2.2-mile-) long tunnels will pass through four intermediate stations between Kaixuan and Tongbo areas of the city. Ground is expected to consist of clay, fine sand, loess and some pebbles, with little ground water.

"The most critical issue for this project is passing under Xi Liu Lake, a large body of water with a depth of 1 to 2 m (3.2 to 6.6 ft). The distance between the bottom of this lake and the top of the tunnel is just 7.0 m (23 ft)," said Steven Zhu, Robbins project manager.

The tunnel will also pass beneath building foundations and a highway interchange bridge. In order to reduce settlement, foam and bentonite will be injected for soil conditioning. The advance rate and the material removed will be continuously and closely monitored to prevent subsidence.

As the machines bore, they will line the tunnel with 300-mm- (12-in.-) thick concrete segments in a 5+1 arrangement. Curves with radii as small as 200 m (656 ft) will be negotiated using active articulation to prevent segment deformation.

Line 1 of Zhengzhou Metro will consist of 26 km (16 miles) of tunnel and 22 stations when complete in 2013. The Zhengzhou Metro Co. has invested Yuan 10.2 billion in the six rail lines, which will total 188 km (117 miles) by their completion between 2015 and 2030.

Two Robbins TBMs will be used at China's Zhengzhou Metro. Tunneling in September.

Veteran Robbins TBM to carve out Faroe Islands Tunnel. The Faroes, a collection of 18 windswept islands in the North Atlantic, are home to nearly 48,000 people. Situated between Iceland and Norway, the mountainous islands receive an average of 250 days of rainfall annually, creating significant runoff. These features make the islands ideal for small hydropower plants utilizing collector tunnels to transport rainwater. The first and only TBM to ever operate in the Faroes, a 3.35-m- (11-ft-) diameter Robbins main beam machine, is extending one such hydropower project with an 8.4 km (5.2 mile) collector tunnel on the island of Eysturoy. A launch ceremony was held in mid-September 2010.

The Robbins TBM, for Danish and Faroese contractors MT Hojgaard and J&K Petersen, was originally purchased in 1984 and has since excavated about 25 km (16 miles) of tunnel for the Eidi Hydropower Plant. The latest project, known as Eidi II, is part of a new green energy initiative by the utility agency for the Faroes: Streymoy, Eysturoy and Vágoy (SEV). The tunnel will collect water from 25 streams, increasing the annual capacity of the plant from about 43 GWh to about 60 GWh.

Prior to startup, the SEV-owned machine underwent some refurbishment to the gearboxes, main bearing, lube system and hydraulic hoses. Robbins is also providing key spare components, including the cutterhead, grippers, hydraulic and lube systems. Robbins field service personnel have also been provided for the project duration.

By October 2010, the machine had excavated several hundred meters of tunnel in basalt rock with no problems. ■

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Hudson River Crossing	NJ Transit ARC Program	Newark	NJ	Subway	8,000 x 2	24.5	2010	Cancelled
Palisades Tunnel	NJ Transit ARC Program	Newark	NJ	Subway	5,400 x 2	24.5	2009	Cancelled
Manhattan Tunnel	NJ Transit ARC Program	New York	NY	Subway	6,000 x 2	24.5	2009	Cancelled
THE 34th St. Cavern & Station	NJ Transit ARC Program	New York	NY	Subway	2,200	100 x 100	2011	Cancelled
Second Ave. 86th Street Station	NYC-MTA	New York	NY	Subway	615	60	2010	Bid date 12/21/2010
Water Tunnel #3	NYC-DEP	New York	NY	Water	24,000	20	2012	Under design
Cross Harbor Freight Tunnel	NYC Regional Development Authority	New York	NY	Highway	25,000	30	2013	Under design
Cross Sound Link Highway Tunnels	Sound Link	Long Island	NY	Highway	190,00	55	2014	Under design
Cross Sound Link Service Tunnel	Sound Link	Long Island	NY	Highway	95,000	38	2014	Under design
Clinton CSO Tunnel	City of Syracuse	Syracuse	NY	CSO	2,000	17	2011	Under design
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2013	Under design
East-West Subway Extension	Baltimore MTA	Baltimore	MD	Subway	32,000	18	2012	Under design
WASA CSO Program Blue Plains Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	23,400	23	2011	Bid date 1Q 2011
Anacosita River Tunnel				CSO	12,500	23	2013	Under design
Northeast Branch Tunnel				CSO	11,300	15	2018	Under design
Northeast Boundry Tunnel				CSO	17,500	23	2021	Under design
North/South Tunnel	Georgia DOT	Atlanta	GA	Highway	77,000	41	2015	Under design
Snapfinger Interplant CSO Tunnel	Dekalb County	Decatur	GA	CSO	26,400	28	2010	Under design
Lockbourne Interceptor Sys. Tunnel	City of Columbus	Columbus	OH	Sewer	10,000	12	2012	Under design
OSIS Aug. & Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	25,300	18	2010	Awarded Kenny/ Obayashi JV
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2012	Under design
Alum Creek Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	74,000	10 - 18	2014	Under design
Black Lick Tunnel	City of Columbus	Columbus	OH	Sewer	32,000	8	2013	Under design
Euclid Creek Tunnel	NEORSD	Cleveland	OH	CSO	18,000	24	2010	McNally/ Kiewit JV low bidder

The editors of Tunneling & Underground Construction encourage UCA of SME members to submit projects to the Tunnel Demand Forecast online at www.smenet.org. The items will be posted on the online TDF once they are verified.

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Dugway Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,000	24	2014	Under design
Lower Mill Creek CSO Tunnel	M.S.D. of Greater Cincinnati	Cincinnati	OH	CSO	9,600	30	2015	Under design
Water Treatment Plant #4	City of Austin	Austin	TX	Water intake	45,000	7 to 9	2010	Bid date 11/12/2010
Waller Creek Tunnel	City of Austin	Austin	TX	CSO	5,300	22	2011	SJ Louis low bidder
Deep Rock Connector Tunnel	City of Indianapolis	Indianapolis	IN	CSO	34,000	18.5	2011	Under design
Pogues Run Tunnel	City of Indianapolis DPW	Indianapolis	IN	CSO	11,000	18	2013	Under design
Drumanard Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200 x 2	35	2012	Under funding review
Drumanard Tunnel - Pilot Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200	12 x 12	2011	Under funding review
Alaskan Way Highway Tunnel	Washington DOT	Seattle	WA	Highway	10,500	54	2011	Final bids submitted
Central Subway Tunnel	S.F. Municipal Trans. Authority	San Francisco	CA	Subway	16,600	20	2011	Under design
San Francisco DTX	Transbay Joint Powers Authority	San Francisco	CA	Transit	6,000	35 to 50	2012	Under design
LA Metro Wilshire Extension	Los Angeles MTA	Los Angeles	CA	Subway	24,000	18	2012	Under design
SVRT BART	Santa Clara Valley Trans. Authority	San Jose	CA	Subway	22,700	20	2011	Under design/ delayed
Kaneoheww Tunnel	Honolulu Department of Env. Services	Honolulu	HI	Sewer	15,000	13	2012	Under design
Spadina Line Extension	Toronto Transit Commission	Toronto	ON	Subway	22,000	18	2010	McNally/Kiewit/ AECON low bidder
Eglinton West Tunnel	Toronto Transit Commission	Toronto	ON	Subway	10 km	20	2011	Bid date 12/01/2010
Yonge Street Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2013	Under design
Port Mann	Greater Vancouver Regional District	Vancouver	BC	Water	3,300	10.5	2010	Final bids submitted
Evergreen Line Project	Trans Link	Vancouver	BC	Subway	10,000	18	2012	Under design
UBC Line Project	Trans Link	Vancouver	BC	Subway	12,000	18	2014	Under design
Kicking Horse Canyon	BC Department of Transportation	Golden	BC	Highway	4,800 x 2	45 x 32	2012	Under design
LRT Expansion North	City of Edmonton	Edmonton	BC	Subway	1,200 x 2	20	2011	Under design

Allentown Powercreter 20 is in production

Allentown Shotcrete Technology Inc. announced that its 2011 version of the Powercreter 20 is now in production.

"This version of the Powercreter 20 has a larger hopper and mixer," said Patrick Bridger, president of Allentown. "These features make projects more efficient for our customers by accommodating larger amounts of material."

Ideal for mid-range pumping requirements, the 2011 model uses the sturdy Thom-Katt frame and the familiar Thom-Katt control box.

"Because the 2011 version incorporates Thom-Katt parts, we determined it would be most efficient to move Powercreter 20 manufacturing to Putzmeister America," added Bridger.

Standard features of the Powercreter 20 include:

Allentown Powercreter 20.

- Hopper capacity of 270 L (9.5 cu ft).
- Rated up to 13m^3/hr (17 cu yd/hour).
- Maximum concrete pressure up to 2,000 psi (138 bar).
- Deutz TD 2011L04i diesel engine.
- Smooth delivery and least pulsation of any shotcrete machine available.
- Easily handles harsh mixes, including low cement, low moisture and refractory pumping castables.
- Can be fed by a ready mix truck, on-site mixer or optional integrated batch or a continuous mixer.

The 2011 version of the Powercreter 20 will be available for order in fall 2010.

www.allentownshotcrete.com

Gyromat 3000 kept Gotthard Tunnel lined up throughout

On Oct. 15, 2010, the last few inches of rock in the Gotthard Base Tunnel were broached. Thus, the breakthrough for this rail tunnel, the world's longest at 57 km (35 miles), was celebrated. Engineers from DMT, the technology services provider based in Essen, Germany, experienced first-hand the completion of the passage for the eastern tube. Their assignment had been to support exact surveying of the tubes far beneath the Swiss Alps. Ever since 2004, DMT has used the Gyromat 3000 high-precision surveying gyroscope at regular intervals to verify measurements in various sections of the tunnel.

"With rock overburdens up to 2,500-m (8,200-ft) thick, the Gotthard Base Tunnel is the deepest rail tunnel anywhere in the world," said the DMT project manager, Volker Schultheiss. "That is why maintaining the correct location, course and altitude while drifting the tunnel was imperative, making high-precision surveying an absolute necessity.

"The tolerances specified for the breakthrough point were 25 cm (10 in.) in the lateral direction and 12.5 m (41 ft) in altitude. Ultimately, the actual deviations in the tunnel were only 8 cm (3 in.) in the horizontal and 1 cm (0.4 in.) in the vertical direction," explained Schultheiss.

The surveying gyroscope was originally developed for high-accuracy surveying of underground galleries in mining operations. This explosion-proof device achieves deviation of no more than 3 cm/km. At its heart is a high-speed gyroscope mounted so as to isolate it from outside forces. Due to the interaction of gyroscope spin, gravity and the earth's rotation, the gyroscope maintains orientation to the north.

The Gyromat 3000 is a fully automatic gyroscopic surveying system, able to specify true north at precision achieved nowhere else (1.5 cm/km). The Gyromat has been employed in a number of tunneling projects beyond pure mining operations including the Eurotunnel underneath the English Channel between France and the United Kingdom. ■

www.gyromat.de

Save the Date

Mark your calendar for these upcoming important industry events. Plan now to attend!

2011

George A. Fox Conference
January 25, 2011 • Graduate Center, City University of New York
New York, New York

Rapid Excavation and Tunneling Conference
June 19-22, 2011 • San Francisco, California

2012

North American Tunneling Conference
June 24-27, 2012 • JW Marriott • Indianapolis, Indiana

For more information contact: UCA of SME
www.smenet.org • meetings@smenet.org • 800-763-3132 • 303-948-4200
8307 Shaffer Parkway • Littleton, Colorado 80127

PERSONAL NEWS

Jacobs Associates has announced the following promotions at the associate level.

RENÉE FIPPIN, P.E., G.E., has 12 years of experience and has specialized in geotechnical and structural excavation support design. She has managed and designed several excavation shoring and temporary structural supports. Currently, she manages San Francisco's Sunnydale auxiliary sewer project.

MICHAEL T. KOWALSKI, P.E., has been with Jacobs Associates for 10 years and has 17 years of experience in the underground industry. In his current role as contracts and corporate insurance manager, he is responsible for reviewing all contracts and billing requirements in addition to managing project controls and insurance certificates.

ANDREW McGLENN, P.E., S.E., P.Eng., has 14 years of experience and is currently leading the design of the permanent tunnel lining for the Airport Link project in Brisbane, Australia. McGlenn has worked on the Brightwater conveyance system project in Seattle, WA, the Northern sewerage project in Melbourne, Australia, the Port Mann water supply tunnel in Vancouver and the University Link in Seattle, WA.

JOHN MURRAY, P.E., has 12 years of experience in underground design and construction management. He recently worked as the design engineer on site at the San Vicente pipeline project in San Diego, CA. He is currently working on the design of the New Jersey Transit Trans-Hudson Express, the Manhattan tunnels project and continues to support the San Vicente Project.

MARK TRIM, P.E., has 12 years of underground design experience. During his five years with Jacobs Associates, he spent nearly four years in Australia, where he split time between projects in Melbourne and Brisbane and helped establish the firm's Melbourne office. Trim is currently working on the Northern sewerage project in Melbourne, Australia and the Kaneohe-Kailua wastewater conveyance project in Honolulu, HI. ■


FIPPIN


KOWALSKI


MCGLENN


MURRAY


TRIM

OBITUARIES

DRUPAD (DRU) DESAI

Drupad (Dru) Desai of Highland, MD died Nov. 2, 2010 in Columbia, MD. During his 45-year career in the tunneling industry, he was a leading civil and geotechnical engineer involved in many working groups, organizations and committees. He was a member of the Underground Construction Association, participating in numerous presentations and panel discussions.

Desai began his career in the 1970s working for Daniel, Mann, Johnson and Mendenhall on the original Baltimore subway system design. Other projects that benefited from his expertise included the H5 highway tunnel in Hawaii, section C of the Baltimore subway and Tren Urbano in Puerto Rico.

Desai established himself as a mentor and trainer for generations of young tunnel engineers. His associates have gone on to work on tunnel projects around the world.

Desai's most recent assignment with AECOM was as chief tunnel engineer for the conceptual and preliminary engineering of the Second Avenue subway project for Metropolitan Transportation Authority Capital Construction in New York, NY. There, he supervised the design of the 13.7-km (8.5-mile) two-track subway alignment. The system will ultimately comprise 16 new stations, six cavern stations and 10 cut-and-cover stations. The full length of the route will be constructed between 125th St. and Hanover Square in the financial district. During the final design of phase one between 96th St. and 63rd St., Desai participated in several peer reviews of the cavern designs for the 86th St. and 72nd St. stations.


DESAI

Desai continued to work as a consultant to AECOM's Tunneling and Underground Technology Group, as his health permitted, through 2008 and 2009. He will be remembered by many for his true professionalism and gentlemanly style.

Desai is survived by his wife, Tarini Drupad Desai; sons, Apurva Desai, Vienna, VA, and Parag Desai, Washington, D.C.; grandson, Rithik Desai and three brothers, Harshad, Dushyant and Janak Desai. ■

March 2011

• **2-3, World Underground Mining Conference,** Beijing, China. Contact: ARA Conference, phone 0086 21 6652 3700, e-mail 17th-dialogue@araworldwide.com, website undergroundminingtech.com.

• **16-18, INTERtunnel 2011,** Moscow, Expocenter, Moscow, Russia. Contact: Natalia Charman, Mack Brooks Exhibitions, Romeland House, Romeland Hill, St Albans, AL3 4ET, Great Britain, phone 440-1727-814-400, fax 440-1727-814-401. e-mail: intertunnelrussia@mackbrooks.com, website www.intertunnelrussia.com.

27-31, NASTT's 20th No-Dig Show, Gaylord National Resort & Convention Center, Washington, D.C. Contact: Michelle Hill, Benjamin Media, Inc. 1770 Main St., P.O. Box 190, Peninsula,OH 44264-0190 USA, phone 330-467-7588, fax 330-468-2289, e-mail mmagyar@benjaminmedia.com, website www.benjaminmedia.com.

More meetings information can be accessed at the SME website — http://www.smenet.org.

May 2011

• **2-5, 29th International No Dig Conference and Exhibition,** Berlin Exhibition Grounds, Berlin, Germany. Contact: Dagmar Eichorn, German Society for Trenchless Technology, Messedamm 22, 14055 Berlin, Germany, phone 490-30-3038-2398, e-mail eichorn@gstt.de, website www. nodigberlin2011.com.

21-26, ITA-AITES World Tunnel Congress, Helsinki, Finland. Contact: Congrex/Blue & White Conferences Oy, P.O.Box 81, FI-00371 Helsinki, Finland, phone 358-9-5607500, fax 358-9-56075020, e-mail wtc11@congrex.fi, website www.wtc11.org.

June 2011

• **19-22, RETC,** San Francisco, CA. Contact: Meetings Department, SME, 8307 Shaffer Parkway, Littleton, CO 80127 USA, phone 800-763-3132 or 303-979-3461, e-mail sme@smenet.org, website www.smenet.org.

May 2012

• **18-23, ITA World Tunnel Congress,** Bangkok Thailand. Contact: Thailand Underground & Tunnelling Group (TUTG), e-mail: info@wtc2012.com, website www.wtc2012.com. ■

Tunneling & Underground Construction INDEX TO VOLUME 4
March, June, September, December 2010
Feature Articles, Industry Newswatch,
News Briefs, Chairman's Column

* Denotes feature article or technical paper

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March

EDITORIAL FEATURES

Northeast US	Tunnel Demand Forecast
Roadheaders	Drills

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CONEXPO - CONAGG	Mar. 22 - 26, 2011	Las Vegas, NV, USA
Coal Prep	May 3 - 5, 2011	Lexington, KY, USA
Rocky Mtn. Coal Mining Institute	Jun 26 - 28, 2011	Keystone, CO, USA
CIM Annual Conference & Exhibit	May 22 - 24, 2011	Montreal, QC, Canada
International Tunnelling Association	May 21 - 26, 2011	Helsinki, Finland

SPECIAL ADVERTISING OFFER

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CLOSES

Sales Close: Tuesday, Feb. 1	Material Close: Tuesday, Feb. 8

June

EDITORIAL FEATURES

Northwest US	Tunnel Demand Forecast
New Austrian Tunneling Method	RETC Preshow and Official Showguides, Pocket Program

BONUS DISTRIBUTION

RETC - Rapid Excavation & Tunneling	Jun. 19 - 22, 2011	San Francisco, CA, USA
Rocky Mtn. Coal Mining Institute	Jun 26 - 28, 2011	Keystone, CO, USA
Extemin / Convencion Minera	Sep. 1, 2011	Arequipa, Peru

SPECIAL ADVERTISING OFFERS

RETC PreShowGuide section	*25% exhibitors*
Official ShowGuide	*Free polybag insert offer with any full page ad purchase*
RETC PocketProgram	*Back Cover, $2,000 – Inside front or inside back cover, $500*
Regular Section	*15% non exhibitors*

CLOSES

Sales Close: Tuesday, May 3	Material Close: Tuesday, May 10

September

EDITORIAL FEATURES

TBM (Tunnel Boring Machine) Equipment	Tunnel Demand Forecast
Tunnel Linings	Grouting

BONUS DISTRIBUTION

Fray International Symposium	Nov. 27 - Dec. 1, 2011	Cancun, Mexico
SME Arizona Conference	Dec. 4 - 5, 2011	Tucson, AZ, USA
NWMA Annual Meeting	Dec. 5 - 10, 2011	Spokane, WA, USA

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15% fractional ad discount

CLOSES

Sales Close: Tuesday, Aug. 2	Material Close: Tuesday, Aug. 9

December

EDITORIAL FEATURES

Midwest US	Tunnel Demand Forecast
Ground Control	Underground Support Systems

BONUS DISTRIBUTION

George A. Fox Conference	Jan., 2012	New York, NY, USA
Canadian Mineral Processors Annual Conference	Jan., 2012	TBD
UCT Annual Conference	Jan., 2012	TBD
SME Annual Meeting & Exhibit	Feb. 19 - 22, 2012	Seattle, WA, USA

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Sales Close: Tuesday, Nov. 1	Material Close: Tuesday, Nov. 8

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Full speed ahead.