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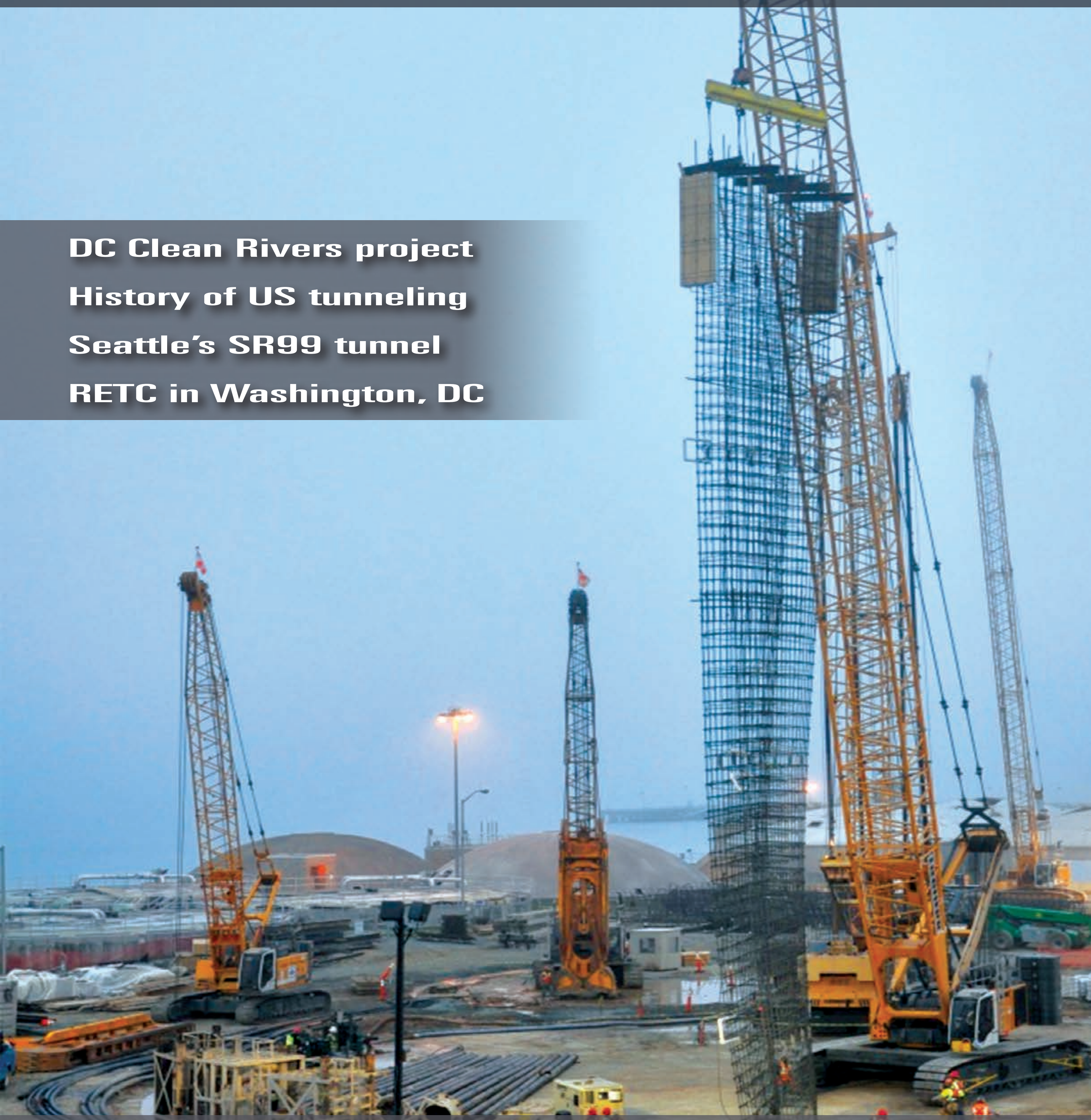
TUNNELING & UNDERGROUND CONSTRUCTION

THE OFFICIAL PUBLICATION OF UCA OF SME   WWW.TUCMAGAZINE.COM   VOLUME 7 NO 2   JUNE 2013



DC Clean Rivers project

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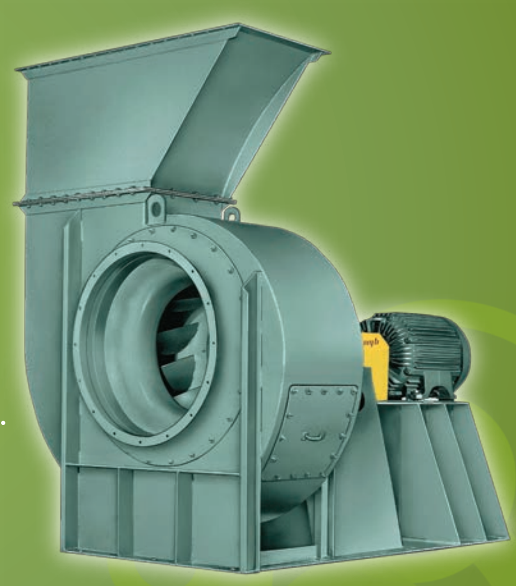

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AN OFFICIAL PUBLICATION OF UCA OF SME WWW.UCA.SMENET.ORG VOLUME 7 NO 2 JUNE 2013

COVER STORY

IN THIS ISSUE — DC Water's Clean Rivers project in Washington, DC is a system of tunnels for the Anacostia River, Rock Creek and the Potomac River that will capture combined sewer overflows. An update is provided on page 14. Tunneling in the United States has been instrumental in the country's growth. David Klug explains, page 23. Cover photo courtesy of DC Water.

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

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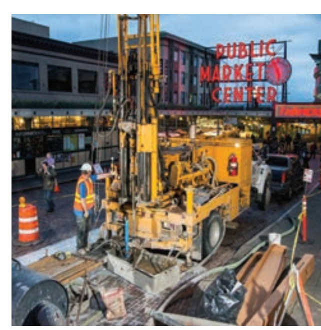

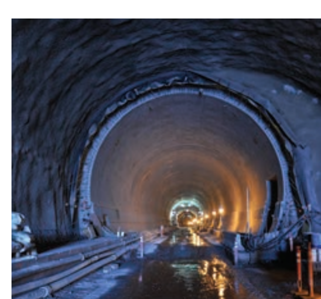

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CHAIRMAN'S COLUMN

RETC is here again and it's time for exciting changes with UCA of SME

By the time you read this, many of you will be on the way to, or in the middle of the RETC conference in Washington, D.C. From my review of the agenda, it looks to be another great conference and a great time to catch up on all things in the underground industry.

It is hard to believe that it has already been two years since I took over the helm as chairman of the Executive Committee for UCA of SME. But it's true — June 2013 will be the two-year mark and also the point at which we rotate the chairman positions on the committee. Change is constant, and change is healthy. I'm glad that I have the opportunity to serve on the executive committee, and I look forward to two more years in the role of past-chairman to do anything we can to help improve our industry.

Personally, I am encouraged by the development of the UCA in recent years, and I hope you see that too. We have had more discussions and lessons learned on safety improvements in my opinion. We have improved scholarship programs and created excellent and consistent conferences to learn and share information and develop our industry. We have seen consistent growth in membership and have built a strong foundation of support by being a division of SME. But I also hope you agree that there is much more that can be done, and that is why I am excited to see what the future holds for the UCA and the tunneling industry as they each continue to grow.

> **Personally, I am encouraged by the development of the UCA in recent years, and I hope you see that too. We have had more discussions and lessons learned on safety improvements in my opinion. We have improved scholarship programs and created excellent and consistent conferences.**

Doug Harding, vice president-sales, The Robbins Co., and Bob Palermo, senior vice president, GZA GeoEnvironmental Inc., will be completing their service on the UCA Executive Committee, and I want to thank them for their years of dedicated service and wish them well in their "day jobs." It is not easy to make the time to give back to the industry, and we appreciate the time that these gentlemen put in to help. Thanks again.

We also have three new members starting on the executive committee this June, and I would like to add my welcome to them: Krishniah Murthy, deputy chief, capital management officer at Los Angles County Metropolitan Transportation Authority; Kellie Rotunno, director of engineering and construction, Northeast Ohio Regional Sewer District and Pam Moran, director of engineering, Wisko America Inc.

Lester Bradshaw, president and treasurer of Bradshaw Construction Corp. and Robert Goodfellow, senior vice president at Aldea Services LLC, have accepted a second term on the UCA Executive Committee.

If you happen to see any of these executive committee members, please join me in thanking them for their service.

I hope that you have a safe and successful participation at this year's RETC. If you are not able to join the event this year, take a break and check out the feature article on the history of tunneling in this issue by Dave Klug (page 23) to get an idea of the impact the industry has had on the United States. ■

Jeffrey Petersen,
UCA of SME Chairman

World's largest TBM arrives in Seattle

On April 2, the world's largest tunnel boring machine (TBM), an $80-million machine from the Japanese firm Hitachi Zosen Corp., arrived in Seattle, WA.

The earth pressure balance (EPB) TBM is 17.6 m (58 ft) in diameter and will be assembled in coming months to begin work on the SR 99 tunnel in Seattle that will replace the Alaskan Way Viaduct, the Washington State Department of Transportation said in a statement.

"We're entering a very exciting phase of the project," said Washington Gov. Jay Inslee. "This brings us one step closer to replacing the seismically vulnerable Alaskan Way Viaduct."

Built in Osaka, Japan, the TBM called Bertha, is owned by Seattle Tunnel Partners (STP), the Washington State Department of Transportation's contractor for the tunnel project. She was taken apart into 41 pieces, the largest weighing about 815 t (900 st), before being loaded on the jumbo Fairpartner in March.

The Fairpartner started its 8,000-km (5,000-mile) journey from Osaka to Seattle on March 19.

Crews at Terminal 46 were expected to spend several weeks offloading the TBM in pieces. The pieces were arranged strategically on the Fairpartner, so that crews unloading the ship can move them to predetermined storage locations within the work zone.

Offloading crews must work around regular port activities, so there could be periods of inactivity or times when the Fairpartner has to leave her spot at the terminal to make room for an incoming cargo ship.

"Construction crews preparing for this machine's arrival have accomplished an unbelievable amount of work over the past 18 months," said state transportation secretary

(Continued on page 12)

Offloading the the TBM cutterhead that will be used for the SR99 Tunnel at Seattle's Terminal 46. Photo courtesy of the Washington State Department of Transportation.

Court sides with King County in tunneling dispute

A Superior Court order awarded King County $14.7 million in legal fees in a dispute over a tunneling project for the Brightwater sewage treatment plant in Woodinville, WA.

The court also denied any post-trial motions to appeal a jury's decision in December to award the county $129.6 million in damages. That action may keep sewage bills from increasing as much in the next few years, according to a county official, *The Seattle Times* reported.

King County filed the lawsuit against VPFK in 2010 with claims that contractors failed to meet deadlines after two tunnel boring machines broke down hundreds of feet into the ground. VPFK — a joint venture of Vinci Construction Grands Projects, Parsons, and Frontier-Kemper Constructors — had been given a $212-million contract to bore two Brightwater tunnels after a bidding process in 2006.

The head of the county's natural resources and parks department, Christie True, has said in the past that the award granted the county could keep sewage bill rates from increasing as much in the future.

"That money would come back, most likely meaning we'd borrow less for a future project," True said in December, when she estimated monthly rates could go up $3.96 by 2015 without the lawsuit money.

Brightwater's $1.8 billion treatment plant opened in Woodinville in 2011. Its 21-km (13-mile) tunnel carries treated waste to Puget Sound. ■

Brierley Associates opens Southern California office

Brierley Associates announced that it has made a strategic hire and is opening an office in southern California to offer its full range of services. The office, the second in California, is located at 6355 Topanga Canyon Blvd., Ste. 309, Woodland Hills, CA 91367.

The office near Los Angeles will be managed by Patrick Smith, Ph.D., GE, who recently joined Brierley Associates. Smith is a Southern California native and understands the unique geotechnical characteristics of the region. Smith has designed, supervised and partici-

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Digging on San Francisco Central Subway is expected to begin in June

Tunnel boring machines (TBM) for San Francisco's Central Subway project arrived in San Francisco in April, with digging expected to begin in June, the *San Francisco Examiner* reported.

Each machine is more than 91-m- (100-ft-) long. They were shipped from China and require an assembly period of four to six weeks, according to Sarah Wilson, an engineer on the project. Once built, the machines will be dropped into a launch box below Fourth Street, where they will start drilling at about 12 m/d (40 ft/day), Wilson said.

Crews of six to nine people will man the massive machines, which will dig as deep as 46 m (150 ft) below the surface. The machines are expected to reach their extraction site in North Beach next April, about 10 months after the start of work.

Along with heralding the arrival of its TBM, the San Francisco Municipal Transportation Agency (Muni) recently announced the return of bids for a massive construction project. All three bids for the work, which includes the construction of three Central Subway stations, came back significantly higher than the agency's original estimate.

Tutor Perini submitted the lowest offer at $840 million and will likely be awarded the work, according to Central Subway project manager John Funghi. Muni projected the work would only cost $720 million to $750 million, although Tutor Perini's bid still falls within budget, Funghi said. That bid will need to be approved by the agency's board of directors.

The $1.6-billion Central Subway project will extend Muni's underground Metro service from south of Market to Chinatown. ■

Breakthrough at Pahang Selangor tunnel

The first of three 5.23-m (17.2-ft) main beam Robbins tunnel boring machines (TBM) broke through at the Pahang Selangor raw-water tunnel on March 22, 2013 to a large ceremony of cheering onlookers, including dignitaries, contractors and honored guests.

The breakthrough is a significant step toward the completion of the longest tunnel in Southeast Asia, a 44.6-km (27.7-mile) water transfer route from the states of Pahang to Selangor.

"This is a day we all look forward to in the tunneling industry … it's a good feeling when you get through all of the hard work and eventually break through," said Andy Birch, Robbins field service manager. "I'm very happy for this joint venture, and they seem very happy too."

Many challenges were overcome by the TBM and its continuous conveyor system on the 11-km (6.8-mile) run, including blocky rock, over-break, power outages, extremely high rock temperature and water inflows. Robbins field service has worked closely with the contractor, a joint venture of Shimizu Corp., Nishimatsu Construction, UEM Builders and IJM Construction (SNUI). Despite the variable conditions, the TBM maintained strong advance rates of 475 m/m (1,560 ft/month) on average. "Advance rates at maximum were more than 650 m/m (2,130 ft/month), that is 30 m/d (98 ft/day) advance," said a senior mechanical and electrical engineer for SNUI JV.

Various methods of support were used during boring, the primary being near-zero rebound fiber mortar (sprayed shotcrete). The Pahang Selangor project marks the first time that this innovative method has been used outside of Japan, and it has been very successful so far. Sprayed shotcrete can be applied during excavation directly behind the cutterhead support, which greatly reduces project downtime. The method also boasts the benefits of dust reduction and good bonding.

The two remaining 5.23-m (17.2-ft) machines are currently boring respective 11-km (6.8-mile) runs, and are on schedule to meet inside the tunnel in autumn 2013. Upon completion, the tunnel will transfer 27.6 m³/s (7,300 gps) of water to a new treatment plant. The drinking water will supply about 7.2 million people for project owner KeTTHA (Malaysian Ministry of Energy, Green Technology and Water). ■

Herrenknecht's Pipe Express wins Innovation Award at bauma 2013

Upon winning the prestigious Innovation Award from bauma 2013, Martin Herrenknecht, chairman of the board of management of Herrenknecht AG, said, "I am absolutely certain that with the Pipe Express method, our young engineers have come up with something the market is looking for. This innovative method for laying pipelines fits perfectly in the global market – it is environmentally friendly, saves construction costs and there is an enormous demand."

A jury of experts consisting of professors in construction, trade journalists and senior executives in the construction industry honored Pipe Express with the bauma 2013 Innovation Award in the machine category. The future viability and the practical relevance of the innovations are assessed for the award. Selection criteria are economic efficiency, increase in performance, energy and resource efficiency, as well as their contribution toward environmental protection, humanizing of the workplace and improving the image of the industry. The competition is a joint project of the German Engineering Federation, Main Federation of the German Construction Industries, German Construction Federation, German Building Materials Association and bauma. Because of the particularly environmentally friendly and cost-effective method of operation, the development of the new system was funded by the German Federal Ministry of the Environment.

Pipe Express is a completely new mechanized method for the near-surface installation of pipelines of up to 1,000 m (3,280 ft) in length and with diameters of 800 to 1,500 mm (32 to 60 in.). A tunnel boring machine (TBM) loosens the soil, which is then directly conveyed above ground using a trenching unit that is carried along. At the same time, the pipeline is installed underground. Since earthwork is reduced to a minimum and no ground water lowering along the route is necessary, Pipe Express has very little impact on the environment. This method is unique for the installation of pipelines with a diameter of up to 1,500 mm (60 in.), the soil is directly removed and not pushed aside. Pipe Express is also ideal for projects in which the ground water level is only a few centimeters below the terrain's surface, in mainly swampy terrain or when nature protection is of special importance.

The main components of the new installation system include a TBM that works underground, a trenching unit with a buggy and an operating vehicle on the terrain surface. The modular design of the entire system allows easy transport and relocation, as well as high flexibility in changing project conditions. The compact system is remotely controlled from the operating vehicle, and no trenches have to be dug. This means that a minimum of heavy earthmoving equipment and manpower are needed, increasing work safety at the same time. ■

DC Water awards $253 million contract for Clean Rivers project

The second largest contract to date for the DC Clean Rivers Project, a $253.9-million contract awarded to the joint venture of Impregilo-Healy-Parsons, was recently approved by the DC Water board of directors.

The contract is for the design and construction of the second portion of the massive tunnel system that will bring relief from combined sewer overflows (CSO) to the Anacostia River. This work is part of the larger Clean Rivers project, a $2.6-billion program to reduce combined-sewer runoff to the Anacostia and Potomac rivers and Rock Creek by 96 percent, the District of Columbia Water and Sewer Authority said in a statement.

"This decision by the board of directors sets in motion a very significant portion of the Clean Rivers Project," said DC Water Board chairman Allen Y. Lew. "This metro-sized tunnel will store combined sewer runoff during intense rainstorms to prevent CSOs to the Anacostia River, improving the health of this important district waterway. In the process, we are also contributing to regional economic growth and creating jobs."

Named the Anacostia River Tunnel, this tunnel portion will be 7 m (23 ft) in diameter, extend 3,810 m (12,500 linear ft) and will cross under the Anacostia River. It begins at Poplar Point and ends near RFK Stadium. Construction will start at the north and work south, connecting to the Blue Plains Tunnel in 2017. The design-build contract also includes six shafts and three diversion structures needed as part of the system.

The first tunnel portion of the Clean Rivers project is already underway. Called the Blue Plains Tunnel, it begins at DC Waters' Blue Plains advanced waste water treatment plant and heads north, where it will eventually meet the Anacostia River Tunnel. Eighty district residents are working for the contractors on the Blue Plains Tunnel. ■

Caterpillar to close former Lovat TBM plant, exit tunneling business

In the wake of a dismal first quarter that saw profits tumble 45 percent, mostly due to low demand for mining equipment, Caterpillar announced that it would close its tunnel boring machine (TBM) facility in Toronto, ON, Canada.

Caterpillar acquired Lovat Inc. in 2008. The closure will result in the loss of 330 jobs at the plant.

Lovat machines have tunneled in Hong Kong, Beijing and Singapore. They have added miles to London's Tube and dug service tunnels for the London and Vancouver Olympics.

Currently, the TBMs from the factory are at work beneath Eglinton Avenue for the new LRT line, and tunneling into Vaughan to push the Spadina subway northward, both in Toronto.

The Caterpillar tunneling plant will cease operations by mid-2014, Caterpillar announced. Parts and technical support will be available until 2016.

The work is not being transferred elsewhere.

In a statement, Caterpillar said it is exiting the business because it "no longer represents a strategic growth opportunity."

Selling the plant was not an option, according to Caterpillar spokeswoman Rachel Potts, who said it "significantly underperformed financially."

"We evaluated selling the business but determined it was not a viable option given the financial underperformance of the business and the landscape of potential buyers," she told the *Toronto Star*.

She would not say whether Caterpillar had asked for bids from potential buyers, nor would she say whether the operation was losing money.

Both the TTC and Metrolinx say that their tunnels will be complete by 2016, when Caterpillar's support winds up.

The TTC used four of the machines on the 8.6-km (5.3

(Continued on page 12)

Jacobs lands contract for Northgate Link

Jacobs Engineering Group Inc. and CH2M Hill, in a joint venture, received a seven-year, $75.5-million contract from Sound Transit of Seattle, WA for the Northgate Link Extension project.

The Jacobs/CH2M Hill team is currently working together on Sound Transit's University Link (U-Link) project, a light-rail extension connecting downtown Seattle and the University of Washington to the north.

The Northgate Link project is extending the line 6.7 km (4.2 miles) farther north from the university to the urban village of Northgate and includes two 5.8-km (3.6-mile) twin-bored tunnels, two underground stations and an arterial guideway with a light-rail station.

"We are very pleased to be selected for this important extension project and to have the opportunity to continue leveraging our resources to deliver high quality construction management services for Sound Transit," said Jacobs Group vice president Kevin McMahon. ■

Brierley: Patrick Smith to lead new office

(Continued from page 4)

pated in numerous geotechnical investigations, including those for intake and outfall systems, as well as for tunnels.

Smith's area of particular interest is near-shore engineering, and he is a member of The ASCE Standards Committee on Seismic Design of Piers and Wharves. He is well-versed in interpretation and quantification of risk associated with geotechnical and geologic hazards (geohazards), as well as in optimizing final design and construction methodology.

Smith has performed a variety of geotechnical engineering analyses for shallow and deep foundations, pipelines, retaining structures, roadways and bridges, slope stability, excavations, seepage effects, and earthquake engineering. He earned his masters and Ph.D. degrees in civil engineering from UCLA. He has published and or presented more than 10 papers on topics related to seismic and earthquake engineering. ■

Caterpillar: Existing Lovat machine still at work

(Continued from page 10)

mile) Spadina subway extension, dubbed Yorkie, Torkie, Holey and Moley.

Metrolinx is also using four machines on Eglinton.

One had been delivered and was due to begin tunneling in May at the west end of the line, with a second due to follow soon.

Two more, to work on the eastern section, will be delivered later this year.

"There is no impact on the schedule for Caterpillar to deliver the TBMs to Metrolinx based on their decision to phase out of business," Metrolinx spokesman Jamie Robinson said in an email.

"However, Metrolinx will be working with Caterpillar to ensure that replacement parts and technical support remains available during tunneling for the Eglinton Crosstown project."

Caterpillar came in for heavy criticism last year when it closed its Electro-Motive diesel locomotive plant in London, ON, Canada.

In that case, the company said labor costs were too high in Canada. It transferred the work to a plant in Muncie, IN.

News of the shutdown came as a shock to Richard Lovat, who founded the company in 1972 after moving to Canada from Italy. He and his son, Rick, ran the firm until selling it to Caterpillar for $49 million in 2008.

Lovat said the company needed to expand, and Caterpillar was the ideal fit to help grow the business: "Instead of an amorphous venture capitalist or bank, interested primarily in asset stripping or maximizing profit without investment, we have a like-minded partner."

The elder Lovat was said he's had no role in the company since the sale and was very surprised to hear of the shutdown.

"You build from scratch and then you sell it," he said. "Then somebody else is running the business, and you've got no control."

"What can you do? They tried to do their best." ■

Seattle: World's largest TBM delivered

(Continued from page 3)

Lynn Peterson. "Thanks to their hard work, tunneling will begin on schedule."

Once crews finish building a 24-m- (80-ft-) deep launch pit, the stored pieces of the machine will be lowered into the pit for reassembly and testing, which will take two to three months. As Bertha's owner, STP is responsible for ensuring she functions properly at all times. Accordingly, she went through a succession of rigorous tests in Japan, one of which revealed a problem with the machine's main drive unit that has since been repaired. Bertha passed all of her tests and will officially become the property of STP once she's successfully tunneled approximately 305 m (1,000 ft).

In addition to building the launch pit, crews in Seattle are preparing the surrounding area for tunneling. That includes strengthening the soil and building protected underground work areas along the initial section of the tunnel route, so crews can perform scheduled inspections of the machine before it begins tunneling beneath the city.

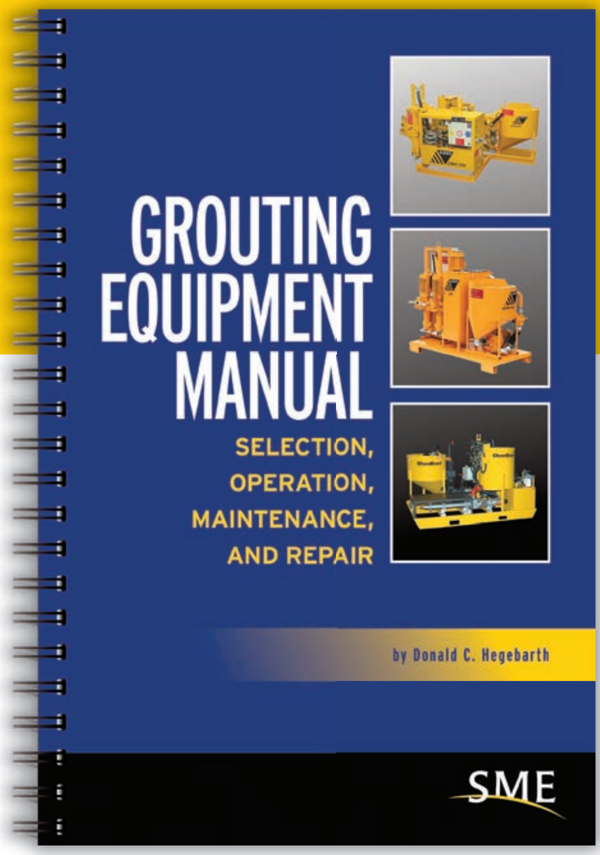
Work is also under way near the north end of the Battery Street Tunnel to prepare the area where Bertha will emerge at the end of tunneling.

For more information about the SR99 Tunnel project, visit http://www.alaskanwayviaduct.org/. ■

GROUTING EQUIPMENT MANUAL

SELECTION, OPERATION, MAINTENANCE, AND REPAIR

by Donald C. Hegebarth



GROUTING EQUIPMENT MANUAL

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2013, 116 pages, 2 lbs.
ISBN: 978-0-87335-367-0
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Pressure grouting is an essential construction procedure that is practiced by contractors and engineers around the world. Used since the 19th century, grouting reduces the amount of leakage through rock for dam foundations and underground works. It also strengthens soils to provide a stable foundation to support the weight of surface structures, such as buildings, bridges, and storage tanks. In addition, it is frequently used to repair deteriorated concrete and to produce concrete underwater.

This manual introduces various types of equipment employed in pressure grouting applications performed in geotechnical works and examines the operating principles and maintenance issues relative to each equipment type.

The term *pressure grouting* encompasses a wide variety of applications and operations, including dam foundation grouting, soil stabilization and permeation, consolidation and compaction grouting (except low-mobility), water cutoff and structural stabilization in rock tunnels, deep foundations via drilled piers, underwater concrete, structural concrete repairs, raising of settled slabs and structures, rock and soil anchors, and machine foundations and bases. The applications for pressure grouting operations are almost limitless, as the equipment can be employed anywhere fluid grout can be used.

Primarily intended for machine operators and maintenance mechanics, this manual will also prove useful to specification writers, engineers, contractors, purchasing managers, and others who have a responsibility to specify, acquire, operate, or maintain pressure grouting equipment. Topics covered include mixers, agitators, pumps, delivery systems and accessories, but not electronic monitoring and other ancillary equipment.

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FEATURE ARTICLE

Construction progress on the DC Clean Rivers project

On Oct. 12, 2011, with federal, regional and local officials present — and a headline banner running in lights across the display in Times Square, NY — the US$2.6 billion DC Clean Rivers Project officially broke ground. Construction began on the 7,378-m- (24,200-ft-) long, 8-m- (26.3-ft-) diameter Blue Plains Tunnel.

Within a year, construction began on a new overflow and diversion structure near RFK Stadium (Division C), a diversion tunnel system on M Street Southeast (Division E), a diversion tunnel beneath Interstate 695 at the 11th Street Bridge project (Division G) and a diversion tunnel on Tingey Street (Division B).

Construction on the District of Columbia's long-term control plan (LTCP) has ramped up significantly over the last two years. The basic design of the program is the conveyance of most overflows to the Blue Plains Advanced Waste Water Treatment Plant via a deep tunnel system. The program is divided into discrete construction contracts, termed "divisions," on the DC Clean Rivers Project. Figure 1 is an overview of the entire system and includes the sections currently under construction. These divisions are:

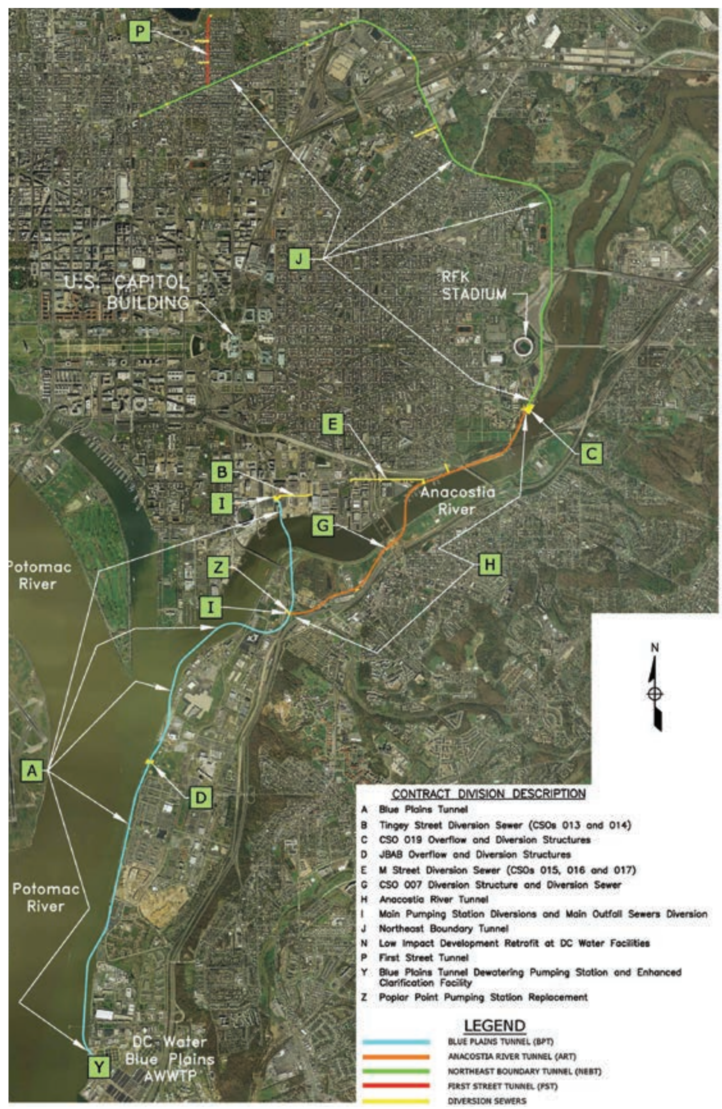
- Division A: The Blue Plains Tunnel. Traylor Brothers is leading a joint venture (JV) with Skanska and Jay Dee to build the first showcase tunnel.
- Division B: The Tingey Street Diversion Sewer. The 1,830-mm- (72-in.-) diameter tunneling work is being performed by Northeast Remsco Construction in close coordination with a developer, Forest City.
- Division C: Overflow Structure at CSO-019. Ulliman/Schutte is performing this work (no tunneling is involved) near RFK stadium.
- Division E: The M Street Diversion Sewer. Corman Construction is the prime contractor and Bradshaw Construction Corp. is doing the tunneling work.

John Beesley, Greg Colzani and Christopher Allen

John Beesley, memmber UCA of SME, and **Christopher Allen**, are program manager-tunnel construction, and assistant director, respectively, with DC Water and Sewer Authority and **Greg Colzani** is oversight construction manager Jacobs Associates, email john.beesley@dcwater.com

FIG. 1

DC Water's Clean River project active construction divisions.



- Division G: CSO-007 Diversion Sewer. Construction is by the DC Department of Transportation for DC Water, with the tunneling work being completed by Bradshaw Construction Corp.
- Division H: The Anacostia River Tunnel. The second big element of Phase 1. Contract award for

this division was awarded in May 2013 to the joint venture of Impregilo/Healy/Parson.

Division A: The Blues Plains Tunnel

The Blue Plains Tunnel (BPT) is the first of two signature tunnels that are the backbone for control of combined sewer overflows (CSOs) into the Anacostia River. The tunnel is being constructed by the joint venture of Traylor Brothers, Skanska and Jay Dee. Shaft construction at the Blue Plains Advanced Waste Water Treatment Plant was the biggest activity in 2012 for the DC Clean Rivers project. Steel-reinforced slurry walls constructed by Bencor provided excavation support for the shafts. The BPT includes a 7,378-m- (24,200-ft-) long, precast-segment-lined tunnel and five shafts. The 8-m- (26.3-ft-) diameter tunnel boring machine (TBM) was manufactured by Herrenknecht and was launched in early 2013.

Division B: The Tingey Street Diversion Sewer

The Tingey Street Diversion Sewer is being constructed in an area of the district that is currently undergoing significant renovation. Revitalization of the area started more than five years ago with the new Nationals Park baseball stadium anchoring the development.

The diversion sewer project, managed by a local developer, Forest City Development Co., will convey two CSOs (#13 and #14) west to the Blue Plains Tunnel (Division A). The tunnel was originally designed to be 1,675 mm (66 in.) in diameter, but the tunneling subcontractor, Northeast Remsco Construction, elected to build a tunnel with a finished diameter of 1,830 mm (72 in.) because of equipment availability. Table 1 summarizes pertinent information regarding the Tingey Street Diversion Sewer.

Tingey Street was once part of the Washington Navy Yard and is in an area that once included a munitions factory and other naval support buildings. Commodore Tingey was commissioned to build the Washington Navy Yard in 1800, and old maps of Tingey Street indicate that some of it was once part of the bay on the north shore of the Anacostia River. Approximately 100 m (330 ft) of the tunnel alignment were wetlands filled in by early builders. The filled area is expected to contain poorly consolidated soil conditions.

To mitigate these conditions, the contract documents require jet grout support columns beneath the sewer pipe to provide long-term support of the pipe. Additionally, a range of unknown manmade materials have been encountered in recent excavations adjacent to the tunnel — including timber, artillery shells, steel debris, concrete blocks, timber piles and rubble. Fortunately, these materials were generally above the tunnel horizon.

The tunnel is also in the vicinity of two brick-lined sewers older than 100 years. Although the sewers have been rehabilitated and lined with shotcrete in the past few decades, their overall structural integrity was a concern. The contractor is required to stabilize one of the sewers by using permeation grout underneath the sewer in the vicinity of the new tunnel. Another sewer that is near the jacking shaft was analyzed using finite element analysis (FEA) for the effect of potential jacking loads on the sewer before tunneling began. The sewer will be monitored during tunneling.

FIG. 2

Tingey Street development.

Because the tunnel alignment passes over the top of the twin Washington Metropolitan Area Transit Authority (WMATA) subway tunnels, it requires a detailed review of the design by WMATA. The subway tunnels were built in the last few decades, and the separation distance from the crown of the subway to the invert of the new tunnel is approximately 13.7 m (45 ft). Ultimately, crossing over the subway is anticipated to have minimal impact on the twin tunnels.

Tingey Street is a rapidly changing corridor that has seen significant construction by Forest City Development Corp. New apartment buildings, a grocery store, mixed use retail and office space are all scheduled to open by the end of 2013. To avoid additional third-party conflicts, DC Water contracted with Forest City to manage the construction of the tunnel so that construction of the sewer could be managed by a single entity, thus allowing concurrent sewer construction with other development construction. Figure 2 is a picture of Tingey Street, taken in late 2012.

TABLE 1

Tingey Street diversion sewer.

Tunnel length: 335 m (1,100 ft)	MTBM: Herrenknecht AVND 1800 AB
Excavated diameter: 2,260 mm (89 in.)	Machine Type: Slurry
Finished diameter:	1,830 m (72 in.) Construction Contractor: Northeast Remsco
Depth (surface to invert) 9.1 m (30 ft)	Design Contractor: CDM Smith

FIG. 3

Overflow structure at CSO #19.

The DC Clean Rivers Project schedule did not require the Tingey Street diversion sewer to be completed as early as it was. However, the developer, Forest City, had a vested interest in accelerating the work to facilitate the opening of several new facilities in the area. A public-private partnership between DC Water and the Forest City Development resulted in award of a guaranteed maximum price (GMP) design-build contract to Forest City.

Northeast Remsco and CDM Smith were subcontracted as the design-build subcontractor for Forest City. The final design work for Division B commenced in the summer of 2012. Forest City established a substantial completion date of October 2013.

Jet grouting was completed in May by Hayward Baker, and tunneling is set to occur in July-August 2013. The concrete diversion structures and remaining work will be completed in the summer and fall of 2013.

Division C: Overflow Structure at CSO #19, RFK Stadium

A large, three-barrel, CSO trunk sewer handling sewer and storm water from the northeast part of DC is managed by a pump station near RFK Stadium. During rain events, large overflows to the Anacostia River occur through what is known as CSO #19. A large diversion and overflow structure is being built at this location to replace the old system. The CSO #19 location is at the northernmost terminus of Phase 1 of the DC Clean Rivers Project. It is required to be completed by March 25, 2018 in order to comply with Phase 1 of the consent decree. Although Division C included construction of a very large concrete structure, as seen in Fig. 3, it does not have an underground construction element. The Division H Anacostia River Tunnel mining shaft will be located on this site as well.

Division E: The M Street Diversion Sewer

The M Street Southeast (SE) Diversion Sewer was the third division to begin construction when Corman Construction of Annapolis Junction, MD, was issued a notice to proceed from DC Water on March 30, 2012. The M Street SE project is scheduled to finish in the summer of 2014. Corman's tunneling subcontractor is Bradshaw Construction Corp. of Eldersburg, MD. The primary characteristics of the M Street Diversion Sewer are outlined in Table 2.

The project includes two tunnels being excavated through mixed face ground conditions of clay, saturated alluvium and fill. Ground modification, by injection grouting prior to tunneling, was specified for two different sections of the diversion sewer.

A location directly beneath an overpass of new Interstate 695 at 12th and M streets needed to be stabilized with grout prior to mining. The initial plan was to drill from above and jet grout from the M Street SE roadway. However, Corman Construction and its geotechnical contractor Hayward Baker devised a plan to grout horizontally from the shaft location at CSO #16. Since the tunnel zone requiring grout is only approximately 19-m- (63-ft-) long, the horizontal grouting concept has a very good chance of success.

The second zone of ground modification was jet grouted from the surface. This zone was about 53.3 m (175 ft).

After completing the tunnel

TABLE 2

M Street SE diversion sewer tunnel characteristics.

Parameter	9th Street to 12th Street	12th Street to 14th Street
Length	308 m (1,010 ft)	400 m (1,131 ft)
Excavated diameter	1,865 mm (73.5 in.)	12 ft (3.7 m)
Excavation equipment	Akkerman Model WM 60-C TBM	Akkerman backhoe/ shield
Ground support	Ribs and boards	Ribs and boards
Ground modification (grout zone)	19 m (63 ft)	53.3 m (175 ft)
Finished diameter	1.2 m (4 ft)	2,185 mm (86 in.)

drives, the tunneling contractor will install fiberglass pipe and fill the annulus with grout. The M Street Diversion Tunnel will join with the Division H Anacostia River Tunnel (ART) through a drop shaft at M Street SE and 14th Street. Figure 4 shows construction at this location where the M Street tunnel will interface with the ART. The Division H drop shaft will be situated at the far end of the channel shown in Fig. 4. In addition to the tunneling, Corman's scope includes diversion structures at CSOs #15 and #16; an open-cut tunnel from CSO #17 to a drop shaft at the future Anacostia River Tunnel (ART, Division H); installation of a new liner in the old, brick-lined Eastside Interceptor Sewer (ESI); and relining of a portion of the Southeast Water Relief Main, a 0.9 m (36 in.) potable water line beneath M Street. Figure 5 shows an access shaft that was constructed by Corman in the summer of 2012 to enable rehabilitation of the ESI.

FIG. 4

M Street open cut and division H shaft location.

Division G: Diversion sewer ACCESS Structures and tunnel at CSO #7

The diversion sewer at CSO #7 is located on the south side of the Anacostia River in the immediate vicinity of Interstate 695, where three, multiple-lane bridges cross the river near the historic Washington Navy Yard. The diversion sewer structures and tunnel were constructed by the DC Department of Transportation (DDOT) in a unique arrangement between DC Water and DDOT. CSO #7 is directly beneath the 11th Street Bridge, and DDOT is performing a large reconstruction effort at that site from 2009 to 2013. The DC Clean Rivers Project and DDOT negotiated a contract requiring DDOT to manage the construction. DDOT issued a change order to Skanska/Facchina, the 11th Street Bridge design-build contractor, to build the structures and tunnel. Facchina Construction of Northern Virginia was the primary subcontractor for the concrete structures, and Bradshaw Construction performed the tunneling and pipe jacking for the 11th Street Bridge project.

The access structures for tunneling were started in the spring of 2012, and Bradshaw pipe jacked the 1,370 mm (54 in.) reinforced concrete pipe (RCP) over an approximately two-month period during the summer of 2012. Two pipe-jacked reaches were required. Reach one crossed beneath Interstate 695 and was approximately 55-m- (180-ft-) long. Reach two crossed beneath a local traffic ramp and extended to a future interface location with the Anacostia River Tunnel. Reach two was approximately 67-m- (220-ft-) long. Although the project was successfully completed in early 2013, the diversion sewer tunnel will not be placed in service until the Anacostia River Tunnel is completed.

The consent decree milestone for completion of the Anacostia River Tunnel and Phase 1 is March 25, 2018. Figure 6 shows the diversion structure where CSO #7 is being diverted to the new tunnel as it was being built in the summer of 2012.

FIG. 5

Typical access shaft on M Street during ESI rehabilitation work.

Division H: The Anacostia River Tunnel

The Anacostia River Tunnel (ART) is the final major tunnel component of the CSO program that must be completed to meet the March 25, 2018 consent decree milestone.

Procurement of the Division H contractor commenced in early 2012. The procurement process included a significant qualification process, leading to a shortlist of three firms selected to submit proposals and costs to construct the project. The three teams selected by DC Water to develop detailed proposals for the Division H contract were:

FIG. 6

Diversion structure at CSO #7, Division G.

TABLE 3

DC Clean Rivers Project diversions under construction.

Division	Description	Approximate value
A	Blue Plains Tunnel	$340,000,000
B	Tingey St. Diversion Sewer	$12,000,000
C	Overflow structure at Eastside pumping station	$25,000,000
E	M St. Southeast diversion structures and sewer	$30,000,000
G	Diversion sewer and Tunnel at CSO #7	$5,000,000

- Impregilo/Healy/Parsons
- Kenny/Shea/Obayashi
- Traylor/Kiewit

The selected design-build teams participated in numerous confidential meetings with DC Water. The goal was to achieve the best product design, at the best price for DC residents, and in the court-mandated time frame available. A stipend will be paid to the two losing firms for their participation in the process. The selection process was completed in the spring of 2013 and the winning team for Division H was Impregilo/Healy/Parsons JV.

The 3,810-m- (12,500-ft-) long tunnel is designed with an inside diameter of 7 m (23 ft). As with the Blue Plains Tunnel, it will be constructed using an earth pressure balance TBM. The tunnel will be driven south from the CSO #19 site near RFK Stadium to the Poplar Point junction shaft, constructed by the Division A contractor (Fig. 7). The tunnel alignment is approximately 30 m (100 ft) below the surface and crosses beneath the Anacostia River, CSX railroad tracks, new Interstate 695, and the WMATA Green Line. Division H will construct six shafts of varying sizes, four diversion structures and three connecting adits of varying length. The tunnel drive will finish at the Poplar Point junction shaft, which was completed by the Division A contractor.

FIG. 7

Popular Point Junction shaft location, fall 2012.

Conclusion

The DC Clean Rivers Project has officially broken ground, and contractors are busy building Phase 1 of the program. The divisions that started construction in 2011 and 2012 and their approximate contract values are summarized in Table 3. The Consent Decree deadline of March 23, 2018 for completion of Phase 1, as established by the District Court for the District of Columbia in 2005, is now only five years away. DC Water is on track to meet the completion deadline for Phase 1 and is confident that the deadline for Phase 2, March 25, 2025 also will be met. ■

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T&UC

FEATURE ARTICLE

Monitoring the SR99 Tunnel project in Seattle, WA

FIG. 1

SR-99 map through Seattle, WA.

Despite its complex and diverse hydrogeology, Seattle,WA has a long history of tunneling and underground construction. The city is currently experiencing an unprecedented tunneling boom.

Tunneling and monitoring have always walked side by side. The real-time monitoring of geotechnical instrumentation started in Europe and Hong Kong in the late 1980s to early 1990s on large urban subway projects. These projects combined several challenges, from underground construction in congested environments to overlapping existing subway lines with new ones. The increase in size of the tunneling machines and the improvement of the technology also required a better control of the settlement. In the early 2000s, the technology appeared in the United States in projects in Boston, MA and New York, but it is now spreading throughout the country and Seattle has been at the front edge of this development on the West Coast.

After the 2001 Nisqually Earthquake damaged the now 60-year-old SR99 Alaskan Way Viaduct, an analysis to replace the aging structure began. It ended in 2009, when the state decided to build a bored tunnel. The approved design of the SR99 tunnel project in Seattle is a 2.9-km (1.8-mile) bore under the heart of downtown using a 17.4-m (57.4-ft) diameter tunnel boring machine (TBM), which is currently the largest diameter TBM ever built. A project of this size requires a state-of-the-art monitoring program.

The instrumentation and monitoring concept originally envisioned by the Washington State Department of Transportation (WSDOT) included heavy monitoring of the ground surface, the underground conditions, the ground pressure on the tunnel lining elements and the structures and buildings in the vicinity of the tunnel alignment. These requirements were then optimized and more heavily focused on building behavior and movement, considered the highest risk in the project's dense urban environment (the SR99 Tunnel goes under Seattle landmarks, including Pioneer Square and Pike Place Market Historic District (Fig. 1)). Furthermore, based on feedback received during one-on-one meetings with bidders, the final request for proposal (RFP) was modified to allow the design-builder to propose alternative instrumentation types or monitoring approaches, with WSDOT's approval.

On Dec. 17, 2010, Seattle Tunnel Partners (STP), a joint venture of Tutor-Perini Corp. and Dragados-USA, was selected by WSDOT in a competitive, best-value

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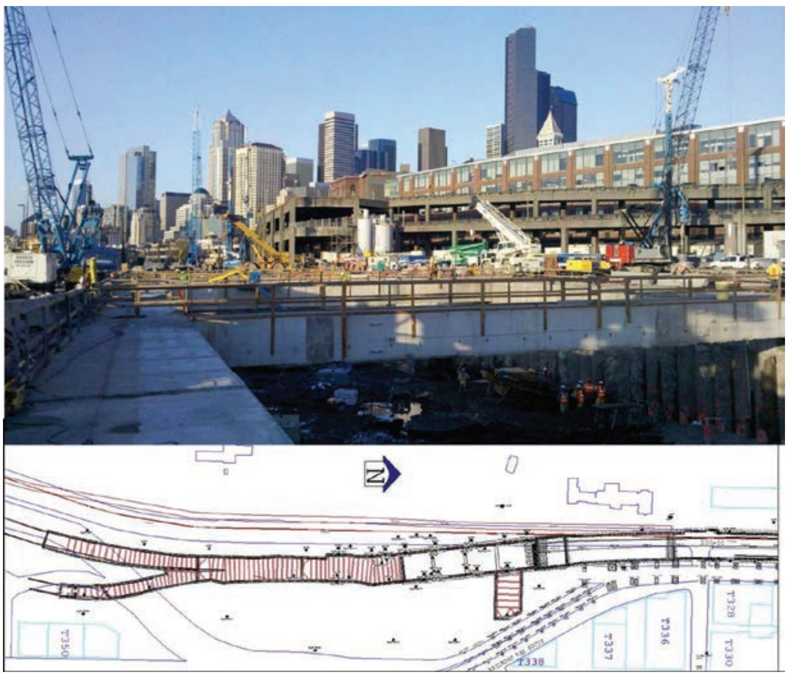
FIG. 2

Overview of the launch pit and plan view.



approach that weighed the design-builder's technical approach and qualifications with the proposal price. STP did not select an instrumentation contractor before the RFP date but chose to finalize this process a few months afterward. SolData Inc., the United States-based subsidiary of Soldata Group and sister company to Nicholson Construction, was hired by STP in September 2011 to monitor tunneling along the alignment. Soldata's references in implementing real-time monitoring programs on similar high-profile urban tunneling projects, such as High-Speed Rail Line 9 in Barcelona, North South Line in Amsterdam, King's Cross and CrossRail in London, KCRC in Hong-Kong and M4 in Budapest, were an important part of STP's decision.

The project is composed of two portals and the excavated tunnel itself. The works started with the excavation of the 122-m- (400-ft-) long launch pit, and the adjacent 335-m- (1,100-ft-) long cut and cover section south of downtown (Fig.2). The monitoring program consisted six monitoring sections spread along the excavation every 91 m (300 ft) on average. Each section consisted of two inclinometer casings installed on each side of the excavation inside the secant pile, two triplets of strain gages installed on each of the two or three beds of steel struts of each section and load cells on each of the tie-back anchors of each section. All the load cells and strain gages are monitored continuously and the inclinometer casings are read manually. Additional inclinometer casings were installed in between these monitoring sections and are monitored at a lesser frequency. In the area of the launch pit where the largest elements of the TBM are supposed to be assembled, two beds of large concrete struts support the excavation and eight strain gages are installed on each and monitored continuously. Eighteen automatic piezometers were also installed inside existing wells to monitor the dewatering operations of the excavation on both sides. Additional manual monitoring points were installed on structures around the excavation. Apart from the existing viaduct monitored with automatic biaxial tiltmeters on each bent and automated monitoring points, there are no existing buildings or structures in the vicinity of the portal, so the monitoring effort was focused on the support of excavation.

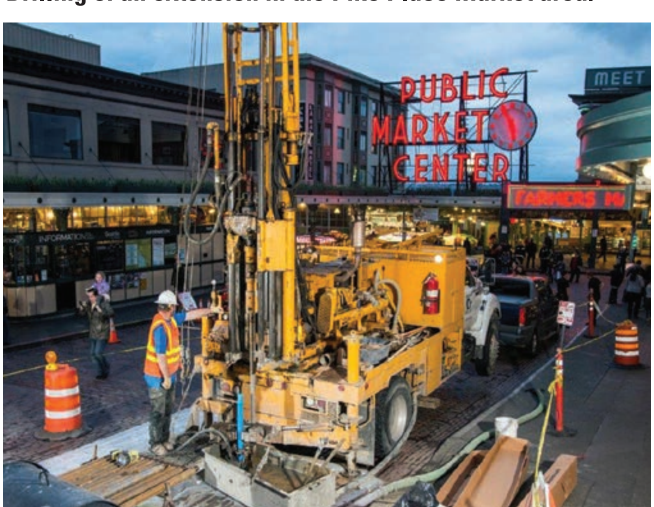
The north portal, smaller than the launch pit, is built with the traditional H-pile lagging wall as the grounwater level is below the actual bottom of excavation. This portal is instrumented with manual inclinometer casings and automated load cells installed on the tie-back anchors.

The larger portion of the monitoring scope is dedicated to monitoring the ground between the surface and the tunnel excavation, as well as the buildings and structures adjacent and above the tunnel alignment.

To monitor the ground settlement on different layers of the ground between the surface and the tunnel crown, 123 automated extensometers are installed (Fig. 3). Most of them have three grouted anchors located 1.5 m (5 ft) above the tunnel crown, 3 m (10 ft) above the tunnel crown and 6 m (20 ft) below the surface. Each anchor is connected to a vibrating wire transducer located in the head of the instruments below the surface. A vibrating wire piezometer is attached to each deepest anchor to

FIG. 3

Drilling of an extension in the Pike Place Market area.



record pore pressure. All sensors are monitored automatically, with a complete data recording and transmission system located in a 30.5-cm (12-in.) diameter traffic rate monument below the road surface. Most of these monuments are located in the busiest downtown streets of Seattle. In addition, in specific monitoring sections along the alignment, in-place inclinometers are located on each side of the tunnel alignment to measure the ground horizontal deflection.

The average boring depth to install these sensors is 61 m (200 ft), with a maximum depth of 91 m (300 ft). The urban constraints to obtain permits and the physical obstructions (below and above ground) made some of these installations a challenge in itself.

Located within the zone of influence of the tunnel excavation are 158 buildings and nine "special structures" (tunnels, bridges or ramps). Most of these structures are monitored continuously. This approach allows assessing the impact of the construction in real-time and taking corrective action to prevent excessive settlement of the structures. The monitoring is performed using automatic motorized total stations (AMTS), the latest hardware technology in 3D movement measurement, combined with a powerful least-square adjustment algorithm that measures movements in the three directions with an accuracy better than 1 mm (0.04 in.) at a 91-m- (300-ft-) distance. This technology is now used on all urban tunneling projects and has progressively replaced the traditional manual survey techniques. These traditional techniques are still used on areas farther away from the tunnel excavation (less likely to be affected by construction). The combination of manual survey techniques and automatic monitoring using AMTS is the best approach to optimize risk management (Fig. 5). Also, for the first time in the United State on this type of project, the AMTS are used to monitor the road surface settlement automatically without the use of reflectors. This optimized use of AMTS, common in Europe on projects like CrossRail, allows a full coverage of 3D movements of buildings using prisms and surface settlement using the reflectorless capabilities of the AMTS. In total, 40 AMTS are being installed along the alignment, most of them on rooftops, and more than 600 3D prisms.

Satellite radar interferometry is another innovative, state-of-the-art technique used on this project to detect settlement caused by tunnel excavation. The interferometry synthetic aperture radar (InSAR) technique has been used for years to detect and monitor large-scale natural hazards (earthquakes, volcanoes and landslides) and in the mapping industry to build digital elevation models. It is only recently that it is being used to measure settlement over extended urban areas during tunnel projects. The technique uses existing

FIG. 4

AMTS located on a roof top monitoring building movements in downtown Seattle, WA.

FIG. 5

Visualization of the global movement monitoring possible with AMTS.

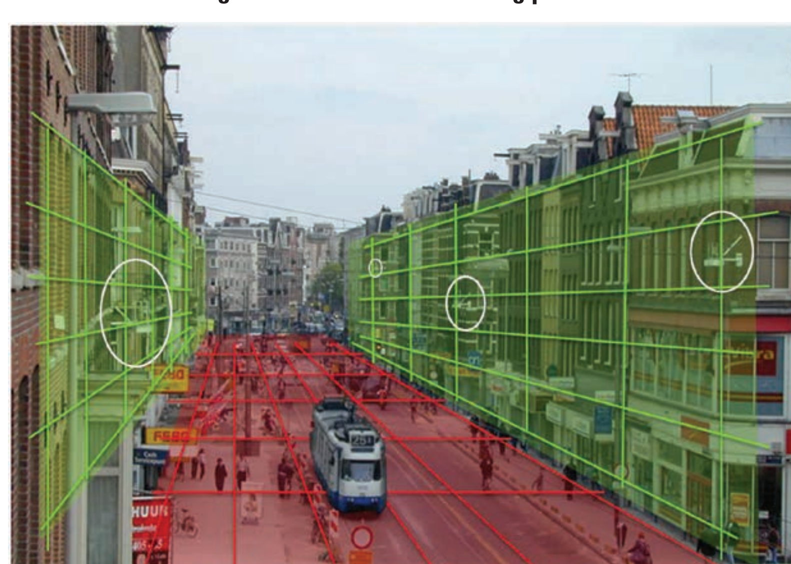


FIG. 6

Visualization of the map of reflectors in the tunnel zone of influence and beyond.

structures or fixed elements as "natural reflectors," with each of these reflectors then being used as a settlement point. With technological advances, the typical density of reflectors is now around 10,000 points/km^2, with one image capturing an area about 5 km^2 (2 sq miles). The accuracy of the technique is better than 3 mm (0.125 in.) Images are taken approximately every 10 days.

Once collected through 3G modems (for the automatic instruments) or downloaded by the project engineers (for the manually read), Soldata uses a comprehensive data management system and monitoring database called Geoscope. Data is analyzed and stored in a dedicated server located in the project's main office in the Wells Fargo building. Data is also backed up several times to prevent any loss of information and is available 24/7 through an Internet application. The Geoscope software filters, checks, validates and sends automatic alerts to inform in real time all the different players of anything outside the expected range of values or above predetermined thresholds. Once the TBM starts, different excavation parameters (grout pressure, shield location will also be stored in the monitoring database and available through the same Internet application). This information system is built to facilitate and accelerate the decision making process with early warnings and graphic visualization. A construction meeting task force will meet every day during tunnel excavation and decide, analyzing the software reports, if any corrective measure needs to be taken. Typical actions include increasing the frequency of monitoring, installing additional instruments, adjusting TBM operating parameters and implementing specific features of this unique tunneling machine, such as shield injection and post-grouting of the liner segments.

Given the scope of the project and its location downtown, the monitoring program is one of the largest implemented in the United States to date. ■

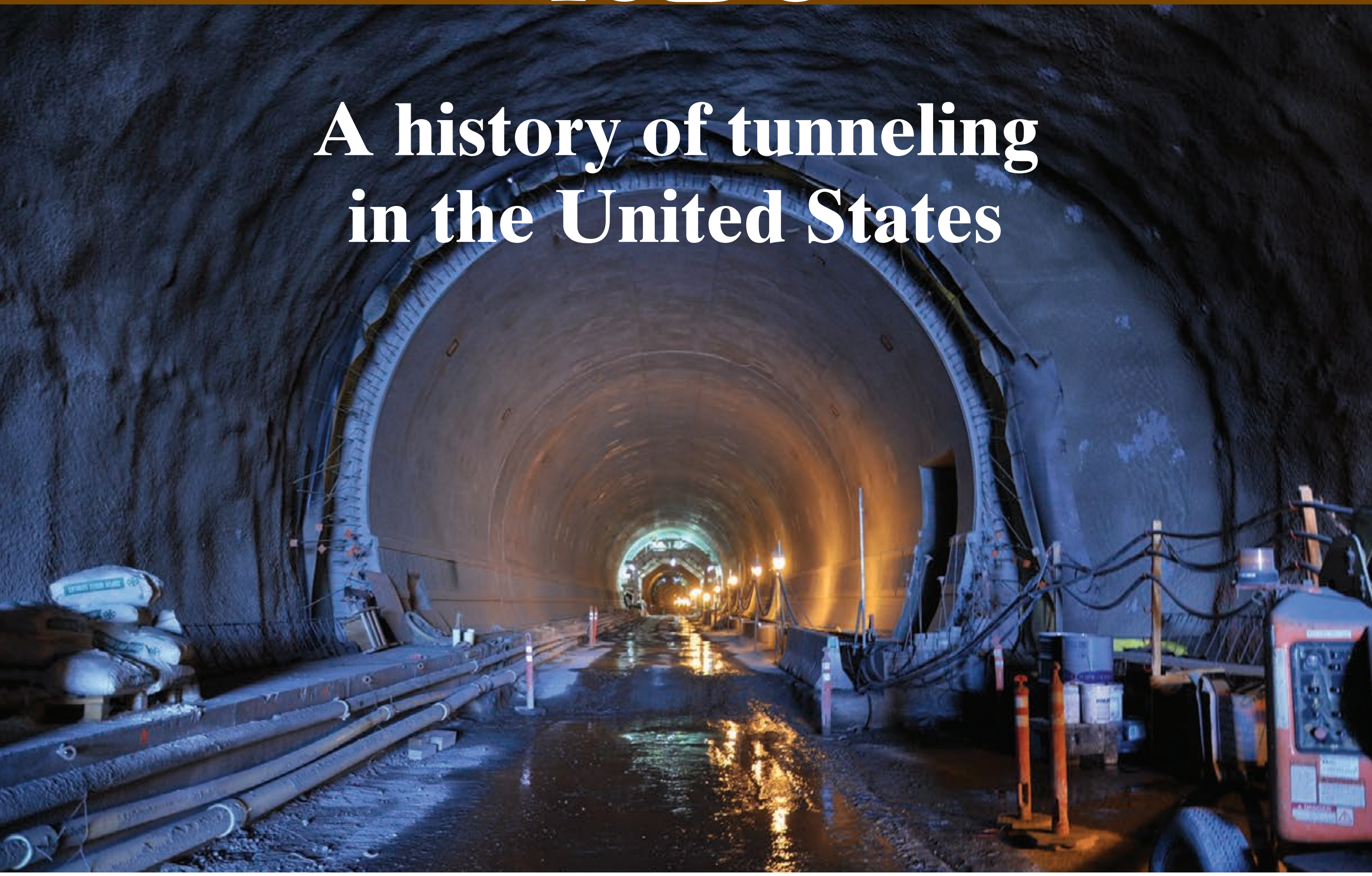
Normet Americas announces complete line of injection technologies

Normet America recently announced that it now has a full line of injection technologies that include microfine cements, ultrafine cements, colloidal silica and a range of polyurethane, urea silicate and acrylate-based grouts in North America.

These injection technologies are part of a range of construction chemicals focused on underground construction and mining. The solutions are designed to be used for the life of the project, from ground treatment of fissured rock or soil and construction of deep box structures, through to tunnel or mine support with sprayed concrete, and finally to maintaining and extending the service life of underground structures.

Normet construction chemical solutions are designed to support all types of tunneling methods, including the tunnel boring machine (TBM), drill-and-blast and mechanical excavations for different rock and soil types. Normet offers a range of foaming and nonfoaming injection resins suitable for stabilizing all rock types including coal, soft and hard rock strata.

Normet's TAM brand prolongs the service life of structures worldwide through the use of high-build mortars, epoxy resins, spray mortars, epoxy mortars and a full range of polyurethane-based resins. Normet also offers a package of watertight solutions, including integral treatment, construction joint systems, surface-applied penetrative treatments, liquid-applied coatings and sheet membranes, guaranteed to waterproof all types of structure. ■



A history of tunneling in the United States

Caltrans Devil's Slide Highway Tunnel in San Francisco, CA was completed in 2012.

Major tunnel projects have been constructed in the United States for more than 150 years. Tunneling made the transcontinental railroad possible, provided access to the center of major urban areas by rail or automobile, made possible the transport of clean drinking water from outside our cities, made urban subway systems efficient and convenient to the public and allowed for the development of underground systems that provided for the transport and treatment of wastewater. Tunnel projects improve the quality of life in our modern society. They not only provide the above noted social benefits, but the construction of tunnels provides many good paying jobs during their planning, design and construction. Tunnel construction has also introduced new technologies to other aspects of heavy construction in the United States.

David R. Klug

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The tunnel industry in the United States is made up of dedicated people who work hard to improve the quality of life for the citizens of the country. The U.S. tunneling industry also cooperates with the international tunneling community for tunneling equipment and new system technologies, plus many foreign contractors have successfully entered the U.S. tunnel construction market in the past years. American engineers and contractors are also involved in many tunnel construction projects outside of the United States, thus demonstrating the competence of our industry.

In a modern society, there is a need worldwide for updated and efficient infrastructure, and tunnel construction has and will contribute to the many infrastructure improvements that are required now and into the future.

The first major tunnel projects were associated with the development of the railway system in the United States, as tunnels were required to negotiate the Allegheny, Rocky Mountain and Sierra Nevada mountain ranges that were challenges to railroad expansion. Railroad expansion was a critical part of the expansion and growth of the U.S. economy in the 19th century, and tunnel construction was one of the key elements in making the railroads a system that served people from all aspects of society. The tunnels were often challenging to build. They were constructed by using new technologies of the era such as air drills and nitroglycerine for drill-and-blast tunnels and shields with cast iron linings for the soft ground tunnels to overcome

The LA Metro Gold Line is part of a project that began in the 1980s with more expansion planned.

the geological obstacles required to complete the projects.

During the late 19th century, Boston, MA was so congested with surface rail vehicles that, in 1892, the Rapid Transit Commission of Boston proposed a subway down Tremont Street. By 1897, the city had a functioning mass transit system that included underground subway tunnels. The city experienced growth, and for the next four decades many tunnels were constructed in Boston to improve the quality of life for the people of the city.

New York City was experiencing the same growth and congestion problems, and the city also turned to tunnels to improve the quality of life for its citizens. Design of the first underground subway for NYC was started by William Barclay Parsons in the late 1890s. The first underground line was opened in 1904. The plan was ambitious, as the initial section was for 14 km (9 miles) and was completed in just four-and-a-half years. Based on the success of the system, the subway was soon expanded to 39 km (24 miles), much of which was tunnel construction. With more than 100 years of service to the people of the New York area, the system is still being expanded to meet the needs of city.

At this same time, the city of New York was constructing Phase I of its fresh water intake system. This system used tunnels to bring water north of New York City to the NYC water distribution system, thus dramatically improving the quality of water for the city.

With the fast assimilation of automobiles into American society beginning in the 1920s, there quickly came a need for highway tunnels to service the needs of the traveling public. The method to construct these tunnels ranged from sunken tube construction, to drill-and-blast for hard rock and cast iron linings for the soft ground tunnels using a shield and compressed air. Examples of successful tunnels built for highway use include the Detroit – Windsor Tunnel that was designed to connect Detroit, MI and Windsor, ON. It was built using sunken tube technology. The Holland Tunnel was designed to connect New Jersey to New York City. The twin tunnels were built using a shielded excavation system and cast iron segment supports to a diameter of 9 m (29 ft, 6 in.) with a length of 2.6 km (1.6 miles). During this period, many tunnels were built to facilitate the automobile and are still in service today, a credit to the design engineers of the time.

During the 1930s, many major infrastructure projects were built in an attempt to stimulate the economy due to the ongoing depression of that period. Major tunnel projects of this period included the Diversion Tunnels for the Hoover Dam project in Nevada, other dam projects in the United States and the Lincoln Tunnel Project in NYC to provide additional automobile and truck traffic access to mid-town New York City. Underground subway/transit projects were constructed in Chicago, IL; Boston, MA; Philadelphia, PA; New York City, NY; Los Angeles, CA and other American cities during this time.

After the end of World War II, there was dramatic growth in the U.S. economy and, thus, in the construction of major infrastructure programs, many of which required tunnels. Some of these projects included the interstate highway program, the Washington, DC subway system (WMATA), the expansion of the NYC subway system, sunken tube highway projects in Norfolk, VA, Baltimore, MD, and the expansion of the subway systems in Los Angeles and San Francisco, CA and Seattle, WA. Beginning in the early 1970s, there was an emphasis on the cleanup of effluent that was previously discharged in the waterways. This has successfully continued to date. Tunnels are used to store and transport effluent so that it can be treated before discharge. During the past 150 years, tunnels have been planned, funded, designed, built — some are still in service — that have improved the quality of life in the United States.

Past tunneling activity in the United States

Tunneling has remained strong in the United States since the early 1950s. Major tunneling programs that have been designed and constructed since the 1950s and have a major impact on our society include:

Washington (D.C.) Metropolitan Transit Authority (WMATA). The system was initiated in 1967 and currently has 175 km (106 miles) of subway track and 86 stations that service the people of Washington D.C., the nation's capital, and the states of Virginia and Maryland. In 1984, NATM /SEM was introduced to the United States on a subway station and line for WMATA. Work is continuing to expand the system to Dulles Airport in Virginia.

Colorado Division of Highways Eisenhower Memorial Tunnel. The system consists of two 2.83-km (1.7-mile) bores through the Rocky Mountains west of Denver, CO. Each bore of the highway project is a two-lane tunnel constructed at an average elevation of 3,400 m (11,158 ft) with crosspassages at 609-m (2,000-ft) intervals. The project was designed in the 1960s and completed in 1973. The tunnels are part of the I-70 Interstate highway system, a critical east-west highway link in the United States.

Colorado Division of Highways Hanging Lake Tunnel. The system consists of two bores through the southern wall of the Glenwood Canyon section of the Rocky Mountains west of Denver, CO. Each two-lane bore has a length of 1.2 km (4,000 ft). Each bore of the tunnel system was constructed by the drill-and-blast method. Membrane tunnel waterproofing was used for one of the first times in the United States in a highway tunnel. The design of the project began in the 1970s, with the project being completed in 1992. The tunnels are part of the I-70 Interstate highway system.

Bay Area Rapid Transit (BART). The system began in 1964 and currently has 114 km (71 miles) of operating systems serving the people of San Francisco and Oakland, CA. The underwater immersed Trans-Bay Tube permits the easy movement of people throughout the metropolitan area. Tunnel construction was a large part of the underwater and downtown program construction. BART is currently planning to expand the system by 53 km (33 miles).

Caltrans Devil's Slide Highway Tunnel. This tunnel consists of twin bores approximately 1.28 km (4,200 ft) of dual-lane highway tunnel with 11 crosspassages and three underground equipment rooms located south of San Francisco, CA. The tunnel is designed to bypass an existing slide area and provide for the safe passage of traffic on historic California Highway No. 1. The tunnel was built with the NATM/SEM construction method in complex geology. A waterproofing membrane was installed, followed by a concrete final lining. The project was completed in 2012.

Chicago Tunnel and Reservoir Plan (TARP) CSO tunnels. One of the largest tunnel programs to take place in the United States has been the epic Tunnel and Reservoir Plan (TARP) in Chicago, IL. The program was designed as combined storm overflow (CSO) system to keep untreated effluent from entering Lake Michigan after rain events that would fill the existing sewer lines. The system is 176.1 km (109.4 miles) long with tunnels that range in diameter from 2.4 m (8 ft) to 10.8 m (35.4 ft). The TARP program was created in 1975, and the construction program has spanned 20 years. The tunnels were constructed in dolomitic limestone and, thus, were very favorable for TBM excavation. More than 30 different TBMs were used to build the system, thus taking advantage of technology to improve the quality of life for the people in the Chicago area.

City of Portland Big Pipe CSO program. In 1993, planning began on the construction of a CSO program to minimize the flow of raw effluent from the city of Portland into the Willamette River. The city developed a three-stage construction plan that built three tunnels — Columbia Slough Big Pipe, 5.8 km (3.5 miles) of 3.65-m- (12-ft-) diameter tunnel; the West Side Big Pipe project, 5.8 km (3.5 miles) of 4.27-m- (14-ft-) diameter tunnel and the East Side Big Pipe project, 10 km (6 miles) of 6.7-m- (22-ft-) diameter tunnel. The city of Portland used innovative contracting models to complete the program in 2010 on schedule and under budget.

Los Angeles County Metropolitan Transportation Authority (LACMTA). The LACMTA currently consists

A tunnel at Tyson's Corner in Washington, D.C. is part of the larger Dulles Airport extension program.

Chicago's TARP project was one of the largest tunnel projects in the history of tunneling in the United States.

of six different lines, with a total system of 141.3 km (87.8 miles). The design of the current system began in the late 1980s, with operations beginning in 1990 after the construction of various underground and opencut tunnels and stations in the downtown area of the city. In the 1990s and 2000s, various underground lines were built to extend the service north and east of the city. Additional expansion is planned.

Sound Transit Subway program. In Seattle, WA, a major subway expansion program is under way. The original program was started in the late 1980s and, in 1996, voters approved a system expansion that would form a 91.6-km (55-mile) regional transit system. Major tunnel projects have been completed to date, inclusive of the Beacon Hill Tunnel and the University Link Extension. Both projects were completed using soft ground TBM technology and one-pass precast segmental tunnel linings. Additional tunnel construction work is planned for 2013 to 2020 to complete the program.

New York City Metropolitan Transportation Authority (NYCMTA). The NYCMTA system is currently the largest in North America, with 337 km (209 miles) of system length. Since the 1950s, the system has expanded to meet the needs of the New York City area, with most of the expansion being underground tunnels due to the congested structures on the surface. The system recovered quickly from the damage that was done during the 9/11 attacks on the World Trade Center site. Major expansion programs will continue to approximately 2017.

Current tunnel activity in the United States

Port of Miami Highway Tunnel Project, Miami, FL. This project consists of two subaqueous tunnels with a length of 1,275 m (4,200 ft). They were driven to 12.93 m (42.3 ft) diameter with an earth pressure boring (EPB) TBM with a one-pass precast segmental tunnel lining installed as the final lining. The contracting model is a public-private-partnership (PPP) between the contractor and the state of Florida. The tunnel is being constructed in porous sedimentary carbonate rock, and an extensive pregrouting program was performed prior to TBM excavation. In November 2011, the first tunnel successfully holed through on the first drive. The project is scheduled to be completed by mid-2014.

NYCMTA No. 7 Subway Extension Project, New York, NY. On the west side of New York City, the NYCMTA is building an extension to the No. 7 Subway Line to service the Javits Convention Center and future development in the area. The $1.2-billion project consisted of the construction 2,895 m (9,500 ft) of 6.86 m (22.5 ft) of running tunnel and a multilevel underground station that has 33.5 m (110 ft) of rock cover. The underground structure is 20 ft (66 ft) wide x 16.5 m (54 ft) high x 268 m (880 ft) long constructed in metamorphic granite with a waterproofing membrane and a cast-in-place final lining. The excavation and final lining placement was completed ahead of schedule. The project will be available for service to the public in 2014 after final fit-out by the NYCMTA.

SFMTA Central Subway Program, San Francisco, CA. The purpose of the program is to expand the service of the SFMTA in downtown San Francisco with an estimated total cost of approximately $1.6 billion. The program consists of the construction of 2.7 km (1.7 miles) of dual-track subway at 6 m (19.5 ft) using a soft ground TBM and one-pass precast segmental tunnel linings. Included in the program are three underground stations, of which two will be constructed with the opencut method and the Chinatown Station being constructed with the NATM/SEM tunnel construction method. The program is scheduled to be completed and opened to the public in 2018.

WMATA Dulles Airport Extension Program, Washington, D.C. The existing subway system is being extended by 38.9 km (23 miles) to connect Washington, D.C. with Dulles International Airport in northern Virginia, with construction occurring in two phases. Phase 1 consists of twin tunnels approximately 731 m (2, 400 ft) of 6.1 m (20 ft) finished tunnel constructed by the NATM / SEM construction method inclusive of a membrane waterproofing system and a cast-in-place final lining. The program is expected to be completed by 2016 at a cost of approximately $3 billion.

Southern Nevada Water Authority (SNWA) Lake Mead Intake Tunnel No. 3, Las Vegas, NV. To address the future water needs of Las Vegas, NV, the SNWA has embarked on a project to construct a third water intake tunnel under Lake Mead. The tunnel is approximately 4.8 km (3 miles) in length with a 6.8-m- (22.3-ft-) diameter one-pass precast lining being installed inside the mix-shield TBM. The TBM and the lining are designed to withstand an external pressure of 17 bar due to the depth of the tunnel under the lake. The project is scheduled to be completed in 2014.

Washington Department of Transportation (WDOT)SR 99 Alaskan Way Highway Tunnel, Seattle, WA. An elevated roadway built in the last century and damaged by recent earthquakes is being replaced by a large diameter tunnel to be constructed under the city of Seattle, WA. Two directions of traffic will be placed in one large tunnel that will provide two levels of multilane traffic service to the public. The tunnel is approximately 1.7 miles (2.7 km) in length and will be constructed using a 58-ft- (17.6-m-) diameter EPB TBM. The tunnel will be constructed and supported with a one-pass precast segmental tunnel lining that will be fitted with the traffic decks and ventilation structures after the completion of the tunnel drive. As of this writing, this tunnel is the largest tunnel diameter TBM tunnel in the world. The project started in 2012 and is scheduled for completion in 2015.

Virginia Department of Transportation (VDOT) Midtown Tunnel Corridor Project, Norfolk, VA. Plans for a new immersed tube tunnel are advancing in Virginia under a PPP contractual arrangement. There will be 11 tube elements, with each element being approximately 16.8-m- (55-ft-) wide x 8.8-m- (29-ft-) high x 91.4-m- (300-ft-) long. The sections will be fabricated in Sparrows Point, MD and floated to the site. The total cost of the project is approximately $2.1 billion, with completion of the project expected in 2016.

IFA Ohio River Bridges Highway Tunnel, Louisville, KY. This project consists of the construction of a modern, twin, two-lane highway tunnel complete with a safety lane for U.S. Route 42 near Louisville, KY. The twin tunnels are approximately 610-m- (2,000-ft-) long x 15.8-m- (52-ft-) wide x 8.23-m- (27-ft-) high. They will be built by the NATM/SEM construction method in limestone with karst features, with a membrane waterproofing and a cast-in-place final lining placed after the initial excavation is completed. Construction will begin in 2013 under a PPP contractual arrangement, with a scheduled completion in 2016.

Future tunnel programs in the United States

There are major tunnel programs being planned for the United States market that should maintain a strong and viable tunnel industry for many years. The following is a summary of some of the major upcoming programs:

LA County Metropolitan Trans. Authority (LACMTA) Subway Expansion Program, Los Angeles, CA

- Crenshaw / LAX Transit Corridor project.The project consists of 3.72 km (2.3 miles) of 6.1 m (20 ft) soft ground tunnel construction to begin in 2013 with completion by 2017.
- Los Angeles Regional Connector project. The project consists of 6.6 km (3.9 miles) of 6.1 m (20 ft) soft ground tunnel.Construction will begin in 2014 with completion by 2018.

Westside Extension program

Phase I consists of 12.8 km (8 miles) of 6.1 m (20 ft) soft ground tunnel – 2018. Phase II consists of 8.08 km (5 miles) of 6.1 m (20 ft) soft ground tunnel – 2019. Phase III consists of 8.08 km (5 miles) of 6.1 m (20 ft) soft ground tunnel – 2020.

CNRA Bay Delta Conservation Plan Water Tunnel Program, Sacramento, CA

Tunnel # 1 consists of 7.92 km (4.9 miles) of 8.84 m (29 ft) soft ground tunnel – 2014. Tunnel # 2 consists of 112.6 km (70 miles) of 10.67 m (35 ft) soft ground tunnel – 2016.

Baltimore Metro Red Line Extension program, Baltimore, MD

West Light Rail Transit Line consists of 12.8 km (7.9 miles) of 6.1 (20 ft) soft ground tunnel – 2015. Cooks Lane Segment Line consists of 4.1 km (2.5 miles) of 6.1 m (20 ft) mixed face tunnel – 2016. Downtown Segment Line consists of 10.9 km (6.7 miles) of 6.1 m (20 ft) mixed face tunnel – 2017.

USDOT High Speed Rail Development Program

There currently exists a program partially funded by the U.S. Department of Transportation to develop high speed rail lines to connect major cities. The initial plan is to begin in California to connect Sacramento, San Francisco and Los Angeles. The program is currently waiting for full federal funding to begin construction. If approved, the program will require many rail tunnels that will benefit the U.S. tunneling industry.

Summary statement

Based on the above information, one will note that the tunneling industry in the United States is strong and will continue to be so into the future. The industry provides quality of life structures that make living in today's modern society possible, and this is true throughout the world. Ours is an international business in which we all benefit when we share our knowledge and experiences with others throughout the world. This is the goal of the U.S tunneling industry. ■

FEATURE ARTICLE

RETC heads to the nation's capital with a full schedule of events

Tunneling projects throughout the world have had a decidedly positive impact of the quality of life for society. Railroad tunnels have allowed economies across the globe to expand, providing people with the goods they need and want. Water and sewer tunnels have, likewise, improved the health of populations. Subway systems in metropolitan areas have provided urban populations the freedom to move about more quickly and easily.

Each tunneling and underground construction project undertaken has added to the knowledge and technology available for tunneling professionals. One of the largest gatherings of tunneling and underground construction professionals will meet in June in Washington, D.C. The Rapid Excavation and Tunneling Conference (RETC) will take place June 23-26 at the Marriott Wardman Park Hotel in Washington, D.C., itself the site of several underground construction projects.

More than 1,400 are expected to attend RETC, June 23-26 at the Marriott Wardman Park Hotel in Washington, D.C.

This biennial conference, of which SME is a sponsor, is expected to attract between 1,400 and 1,500 attendees from around the world. These professionals represent all aspects of the global tunneling and underground construction industries — owners, contractors, equipment suppliers.

Steve Kral,
Editor

More than 110 technical papers in 22 sessions will be presented over two-and-a-half days. Paid attendees will receive a proceedings volume of the conference. The proceedings will also be available from SME. In addition to the technical programming, the accompanying exhibit has grown to more than 185 booths, providing RETC attendees the opportunity to get a look at the latest in equipment and service technology. Four short courses will be held on the Sunday preceding the start of the show. And there will be plenty of opportunities for attendees to meet and chat during several social activities that are scheduled throughout the conference.

Short courses and field trip

Four short courses are planned for Sunday, June 23 at the Marriott Wardman Hotel. Included with each are course notes/materials, professional development hours and a certificate of completion.

Grouting in Underground Construction will present an overview of the materials, equipment and the various grouting methods used in association with underground construction in soils and rocks. Nine experts will provide lectures on different grouting techniques.

Tunnel Lining Design presents an overview of the latest developments in tunnel lining design and installation. National and international experts will present course topics.

Microtunneling Application will introduce microtunneling construction methods and processes, equipment requirements, project planning, design concepts and considerations and construction challenges. This course is aimed at engineers, owners and contractors.

Risk, Uncertainty and Hard Decisions will help attendees to better understand risks, uncertainties involved with tunneling projects, along with human behavior uncertainties. Instructors will use models, case studies and class exercises. Twelve panelists will participate in the lectures — contractors, engineers, consultants and owners.

Attendees of the half-day field trip, planned for Wednesday afternoon following the technical sessions, will visit DC Water's Blue Plains tunnel project. Blue Plains is one segment of DC Water's Clean Rivers project. Clean Rivers is comprised of a system of tunnels for the Anacostia River, Rock Creek and the Potomac River that will capture combined sewer overflows for treatment at the Blue Plains site.

Among Blue Plains' components is a 23-m (76-ft) screening shaft to help mine the tunnel and an adjacent 430-m (132-ft) dewatering shaft. About 7,315 m (24,000 ft) of tunneling is planned for the site with a minimum diameter of 7 m (23 ft). Also included in the project are a tunnel overflow/drop shaft, a combined drop/junction shaft, a surge chamber and an approach channel located near Poplar Point. A drop shaft at DC Water's main pumping station near Second and Tingey streets will be used to retrieve the tunnel boring machine.

Technical programming

RETC's technical program kicks off Sunday afternoon with two special sessions. Contracting Practices includes four papers, chaired by B. Cowles, of Jacobs Civil; and D. McMaster, of Hatch Mott MacDonald. The second session, Risk Management, also includes four papers and will be chaired by E. Wang, of Jacobs Engineering Group; and D. Zoldy, of AECOM.

Regular technical programming begins Monday morning with four sessions. They are Difficult Ground, Geotechnical Considerations, New and Innovative Technologies I, and Pressure Face TBM Case Histories I. Afternoon sessions are Caverns and Large Spans, Geotechnical Instrumentation: Settlement Control, New and Innovative Technologies II and Pressure Face TBM Case Histories II.

Tuesday morning's sessions include Ground Stabilization, Hard Rock Tunneling, Pressure Face Technology, and Tunnel Finishing and Liner Installation. Four sessions in the afternoon include Grouting: Water Control, Precast Tunneling Linings, SEM/NATM and Shafts.

RETC's technical programming ends Wednesday morning with four sessions. They are Design and Planning, Future Projects, Major Projects, and New Plant and Equipment Applications.

In addition to 110 technical sessions, attendees will be able to visit 185 exhibitors at RETC in June.

Welcoming lunch and social activities

Victor M. Mendez is scheduled to be the welcoming luncheon speaker on Monday. He is administrator of the Federal Highway Administration (FHWA). His agency, comprised of more than 2,900 employees, oversees funding for infrastructure projects across the nation.

Mendez directed the FHWA's implementation of President Obama's American Recovery and Reinvestment Act of 2009. This program made available $26.6 billion for bridge and highway projects in the United States. Its goal was to help revitalize the nation's infrastructure and create jobs through more than 13,000 projects.

On Tuesday morning, the Underground Construction Association of SME (UCA) will hold its breakfast. There, UCA chairman Jeffrey Petersen will update attendees of the division's activities during the past year. The UCA will also present its scholarships to Sean Warren, Hamed Zamenian and Hamed Lashkari. And William Edgerton will be inducted as the UCA's incoming chair. The UCA will host its corporate and sustaining member reception on Sunday evening.

The 2013 RETC will conclude Wednesday evening with the annual banquet. The evening's entertainment will be the Capitol Steps, a group of former Capitol Hill staffers who have turned their talents to lampooning the people they used to work for. The group has recorded several albums, including *Take the Money and Run for President*, and *Barackin Around the Christmas Tree*. Taken together, members of the Capitol Steps have worked in 18 congressional offices and have 62 years of combined experience of House and Senate staff experience.

Other social activities include luncheons in the exhibit hall on Tuesday and Wednesday and hosted receptions on Monday and Tuesday, also in the exhibit hall. ■

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel project	Amtrak	Newark	NJ	Subway	14,600	24.5	2015	Under study
2nd Ave. Phase 2-4	NYC-MTA	New York	NY	Subway	105,600	20	2015-20	Under study
Water Tunnel #3 bypass tunnel	NYC-DEP	New York	NY	Water	20,000	22	2015	Under design
Water Tunnel #3 Stage 3 Kensico	NYC-DEP	New York	NY	Water	84,000	20	2017	Under design
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Highway	25,000	30	2016	Under study
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2018	Under design
Hartford CSO	MDC	Hartford	CT	CSO	32,000	20	2014	Under design
South Conveyance Tunnel	City of Hartford	Hartford	CT	CSO	16,000	26	2015	Under design
Red Line Tunnel - Cooks Lane Tunnel	MD Transit Administration	Baltimore	MD	Subway	14,000	22	2015	Under design
Red Line Tunnel - Downtown Tunnel	MD Transit Administration	Baltimore	MD	Subway	36,000	22	2015	Under design
Purple Line - Plymouth Tunnel	MD Transit Administration	Baltimore	MD	Subway	1,000	30x40	2015	Under design
Anacostia River Tunnel Northeast Branch Tunnel Northeast Boundary Tunnel First Street Tunnel	DC Water and Sewer Authority	Washington	DC	CSO CSO CSO CSO	12,500 11,300 17,500 17,500	23 15 23 23	2013 2018 2021 2021	Awarded to I-H-P JV Under design Under design Pre Qual under way
Biscayne Bay Tunnel	Miami Dade Water and Sewer Dept.	Miami	FL	Sewer	5,200	12	2013	Under design
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2014	Under design
Blacklick Creek San. Interceptor Tunnel	City of Columbus	Columbus	OH	Sewer	24,000	10	2014	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2015 2017	Under design Under design
Dugway Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,000	24	2013	Under design
Doan Valley Storage Tunnel	NEORSD	Cleveland	OH	CSO	9,700	17	2015	Under design
Westerly Main Storage Tunnel	NEORSD	Cleveland	OH	CSO	12,300	24	2020	Under design
Lower Mill Creek CSO Tunnel - Phase 1	M.S.D. of Greater Cincinnati	Cincinnati	OH	CSO	9,600	30	2014	Under design
Ohio Canal Tunnel	City of Akron	Akron	OH	CSO	6,170	27	2014	Under design
Northside Tunnel	City of Akron	Akron	OH	CSO	6,850	24	2021	Under design
ALSCOSAN CSO Program	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	35,000	20	2016	Under design

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Pogues Run Tunnel	Indianapolis DPW	Indianapolis	IN	CSO	9,700	18	2016	Under design
White River Tunnel	Indianapolis DPW	Indianapolis	IN	CSO	27,800	18	2016	Under design
St. Louis CSO Expansion	St. Louis MSD	St. Louis	MO	CSO	47,500	30	2014	Under design
KCMO Overflow Control Program	City of Kansas City, MO	Kansas City	MO	CSO	62,000	14	2014	Under design
Mill Creek Peaks Branch Tunnel	City of Dallas	Dallas	TX	CSO	5,500	26	2014	Under design
North Link Light Rail Extension	Sound Transit	Seattle	WA	Transit	35,000	22	2014	Bid date 5/30/13
East Link Light Rail Extension	Sound Transit	Seattle	WA	Transit	30,000	22	2016	Under design
Chinatown NATM Station	San Fran. Muni Transit Authority	San Francisco	CA	Subway	340	60	2013	Tutor-Perini low bidder
Third Ave. Subway Tunnel	San Fran. Muni Transit Authority	San Francisco	CA	Subway	10,000	22	2015	Under design
L.A. Metro Regional Connector	Los Angeles MTA	Los Angeles	CA	Subway	20,000	20	2014	Bid date 6/25/2013
LA Metro Wilshire Extension Phase 1 Phase 2 Phase 3	Los Angeles MTA	Los Angeles	CA	Subway	42,000 26,500 26,500	20 20 20	2014 2015 2017	Pre Qual underway Under design Under design
LA CSO Program	L.A. Dept. of Public Works	Los Angeles	CA	CSO	37,000	18	2015	Under design
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2016	Under design
SVRT BART	Santa Clara Valley Trans. Authority	San Jose	CA	Subway	22,700	20	2014	Under design/ delayed
BDCP Tunnel #1 BDCP Tunnel # 2	Bay Delta Conservation Plan	Sacramento	CA	Water	26,000 369,600	29 35	2015 2017	Under design Under design
Kaneohe W.W. Tunnel	Honolulu Dept. of Env. Services	Honolulu	HI	Sewer	15,000	10	2013	Bid mid 2013
Eglinton-Scarborough Tunnel	Toronto Transit Commission	Toronto	ON	Subway	40,500	18	2014	Under study
Yonge St. Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2016	Under study
Hanlan Water Tunnel	Region of Peel	Toronto	ON	CSO	19,500	12	2013	Pre Qual JV's announced
West Trunk Sewer Phase 1 West Trunk Sewer Phase 2	Region of Peel	Toronto	ON	Sewer	30,000 16,000	11 11	2013 2013	McNally low bidder Ad 3rd Q 2013
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Under design
Evergreen Line Project	Trans Link	Vancouver	BC	Subway	10,000	18	2012	Prequalified JV's announced
UBC Line Project	Trans Link	Vancouver	BC	Subway	12,000	18	2015	Under design
Kicking Horse Canyon	BC Department of Transportation	Golden	BC	Highway	4,800 x 2	45 x 32	2015	Under design

UCA of SME Sustaining Members

The UCA of SME wishes to thank its Corporate and Sustaining Member companies. Their support for the underground construction industry and its professionals is sincerely appreciated.

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For more information on these companies and/or UCA of SME membership, contact uca.smenet.org, emas@smenet.org, 303.948.4200.

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RETC 2013 Proceedings

2013, Published by SME, 12999 E. Adam Aircraft Cir., 80122, Englewood, CO, USA, www.smenet.org/store, email books@smenet.org, phone 303-948-4225.

Edited by Michael A. DiPonio and Chris Dixon, 1,364 pages plus CD, 4 lbs, ISBN: 978-0-87335-383-0, Book Order No. 383-0, $139 member $119 student member, $179 nonmember/list.

Every two years, underground construction and tunneling industry leaders and practitioners from around the world gather at the Rapid Excavation and Tunneling Conference (RETC), the authoritative program for the tunneling profession, to learn about the most recent advances and breakthroughs in this unique field.

This comprehensive book includes more than 100 papers from industry experts, highlighting their most recent projects and sharing real-world experiences that will keep you up-to-date on the latest tunneling trends and technologies.

This book digs deep into every aspect of the business, presenting practical, no-nonsense information about demanding and high-profile projects. From caverns and large spans, contracting practices, tunnel linings, and design and planning to geotechnical considerations and instrumentation, ground stabilization, equipment applications, and risk management, this proceedings has the cutting-edge and innovative information you should have to meet the needs of the ever-important tunneling field.

As with past conferences, a significant number of the papers are by international authors, providing insight into projects and practices from across the globe. A fully searchable CD containing the entire proceedings is also included.

The book will be useful for engineers, designers, geologists, contractors and others who want to learn how their colleagues are addressing the challenges of the profession.

Grouting Equipment Manual

2013, Published by SME, 12999 E. Adam Aircraft Cir., 80122, Englewood, CO, USA, www.smenet.org/store, email books@smenet.org, phone 303-948-4225, 2013, 116 pages, 2 lbs. ISBN: 978-0-87335-367-0, Book Order No. 367-0, $69 member, $59 student member, $89 nonmember/list.

Pressure grouting is an essential construction procedure that is practiced by contractors and engineers around the world. Used since the 19th century, grouting reduces the amount of leakage through rock for dam foundations and underground works. It also strengthens soils to provide a stable foundation to support the weight of surface structures, such as buildings, bridges and storage tanks. In addition, it is frequently used to repair deteriorated concrete and to produce concrete under water.

This manual introduces various types of equipment employed in pressure grouting applications performed in geotechnical works and examines the operating principles and maintenance issues relative to each equipment type.

The term pressure grouting encompasses a variety of applications and operations, including dam foundation grouting, soil stabilization and permeation, consolidation and compaction grouting (except low-mobility), water cutoff and structural stabilization in rock tunnels, deep foundations by drilled piers, underwater concrete, structural concrete repairs, raising of settled slabs and structures, rock and soil anchors, and machine foundations and bases. The applications for pressure grouting operations are almost limitless, as the equipment can be employed anywhere fluid grout can be used.

Primarily intended for machine operators and maintenance mechanics, this manual will also prove useful to specification writers, engineers, contractors, purchasing managers and others who have a responsibility to specify, acquire, operate or maintain pressure grouting equipment. Topics covered include mixers, agitators, pumps, delivery systems and accessories, but not electronic monitoring and other ancillary equipment. ■

OBITUARY

THOMAS W. TRAYLOR

In memoriam by his family

Thomas W. Traylor, 73, of Evansville, IN, passed away May 9, 2013 at Select Specialty Hospital surrounded by his wife and sons.

He was a devoted husband, and a loving and supportive father and grandfather. He loved coaching soccer for all of his sons and was a advocate and supporter of Evansville-area soccer programs. A member of Holy Redeemer Parish, he was a devout Catholic and very supportive of Catholic education and ministry.

Traylor will be remembered as a brilliant business man, engineer and entrepreneur. He received his B.S. degree in civil engineering from the Massachusetts Institute of Technology in 1961 and his M.B.A. from Stanford University in 1963. He helped to catapult Traylor Bros. Inc., a company founded by his father William in 1946, into one of North America's leaders in underground, marine and bridge construction. A testament to his many engineering contributions, he was honored in 2008 by The Beavers with the prestigious Beavers Management Award and, in 2010, he was honored by The Moles for his outstanding achievement in construction. He was nominated for both awards by his colleagues.

TRAYLOR

Traylor was a member of other fraternal organizations of construction and engineering professionals, such as the Construction Industry Round Table, the National Academy of Construction and the American Society of Civil Engineers. He also served as president of The Beavers organization.

Traylor was a member of the World Presidents Organization and Chief Executive Organization, and he served as director on community, national and university boards, including Fifth Third Bank and the University of Evansville. He and his wife Nancy generously supported civic and community organizations such as the Juvenile Diabetes Research Foundation, the United Way, WNIN, the Evansville Museum and the Evansville Philharmonic Orchestra — an organization that represented his appreciation for music and the arts. Their history of philanthropy is also evident at Evansville Day School, Reitz Memorial High School and the University of Evansville, as well as other educational institutions that touched their lives.

A man with many interests, Traylor had a passion for flying and obtained his instrument rating to fly his own plane. He and his wife were avid travelers, visiting many sites throughout the United States and around the world. He was a voracious reader on a variety of topics.

Traylor is survived by his wife, Nancy Sartore Traylor, and sons Thomas William Jr., Michael Thomas, Christopher Scott and Daniel Allen. Also surviving are a brother, Glen Robert Traylor, and sister, Suzanne Teater. He was lovingly known as granddad by his 13 grandchildren. ■

2013 ANNUAL MEETING

UCA presents 10 papers at the SME Annual Meeting

By Raymond Henn, UCA session chair

The Underground Construction Association (UCA) of SME had a good showing in Denver, CO at the 2013 SME Annual Meeting held in February. The UCA had two sessions, one in the morning and one in the afternoon, in which 10 technical papers were presented. Ray Henn, from Brierley Associates, and Bob Stier, from Kiewit Infrastructure, chaired the sessions.

The papers presented included:

- **TBMs in mining application**, by Dennis Ofiara, The Robbins Company.
- **Tunnel grouting**, by Bill Warfield, Atlas Copco.
- **Recent mine plugs in Colorado,** by Warren Harrison, WLH Construction.
- **Using foam to transport tailing,** by Rich Palladino, Cellular Concrete Solutions.
- **Hard rock TBMs for deep, long distance tunnel**, by Werner Burger, Herrenknecht AG.
- **Challenges in coal mine slope construction**, by Neal Wedding and Jason Haynes, Frontier-Kemper Constructors.
- **Hard rock double shield for Gran San Bernardo service and safety tunnel between Italy and Switzerland,** by Walter Trisi and Fawaz Killu, Caterpillar Tunneling Canada.
- **High-quality precast concrete tunnel liners**, by Len Worden, CSI.
- **Disc cutter monitoring on hard rock tunnel boring machines,** by Hamed Lashkari, The Pennsylvania State University, and Steve Smading and Aaron Shanahan, The Robbins Company.
- **Roadheader performance on the Caldecott fourth-bore tunnel**, by David Kwietnewski, Brierley Associates.

Thank you very much to each presenter. All of the papers were great. Henn and Dave Klug will be chairing two UCA sessions during the 2014 SME Annual Meeting, which will be held in Salt Lake City, UT. The focus topics of the two sessions are still being developed by Henn and Klug. ■

PERSONAL NEWS

HEADLAND

Aldea Services is continuing to expand, adding two new partners to keep up with the rising demand for the specialized services offered by the firm. **MOHAMED YOUNIS**, P.E. (SME) and **PAUL HEADLAND**, P.E., P.G. (SME) have been elevated to partners in the firm, joining **ROBERT GOODFELLOW** (SME) and **GINA GOODFELLOW** in the ownership group. Headland joins the Maryland operation as vice president of geological services and offers more than 20 years of experience in tunneling and mining. He has specialized expertise in microtunneling and trenchless design and construction as well as ground behavior and geological characterization for all types of tunnels.

YOUNIS

GOODFELLOW

Younis is vice president, tunnel and geotechnical engineering. He has more than 20 years of North American and international experience in tunnel engineering management, design and consultation. Younis has managed and led the design for major tunneling projects including Dubai Metro, WSSC Bi-County Water Tunnel and Kolkata Metro.

MONGE FABIAN

Aldea has also added two engineers to its staff. Recent Colorado School of Mines graduate **GUADALUPE MONGE FABIAN** has joined the Columbus, OH office and **ROOZBEH YOUSEFZADEH** P.E., has joined as a structural engineer in the new Frederick, MD office along with the office administrator, **LESLIE SULLAM**. ■

YOUSEFZASEH

cutting edge

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2013 CONFERENCE ON **MEGAPROJECTS**

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Mark your calendar today!

10% of the profits from this event will be donated to the UCA of SME's Student Scholarship Fund

For more information about the conference, exhibit or sponsorship opportunities, please contact:

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UCA of SME

north american Tunneling journal

ADVERTISER INDEX • JUNE 2013

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Applicants must possess an earned Ph.D. degree in an engineering discipline. Background and expertise in one or more of the following areas of specialization is required: underground construction, tunneling, site investigations, excavation engineering, tunnel design/instrumentation, machine and cutter design, and ground support/lining design.

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• Abstract of 100 words or less •
• The topic to which it applies •
• Complete contact information for corresponding author •
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