T&UC

TUNNELING & UNDERGROUND CONSTRUCTION

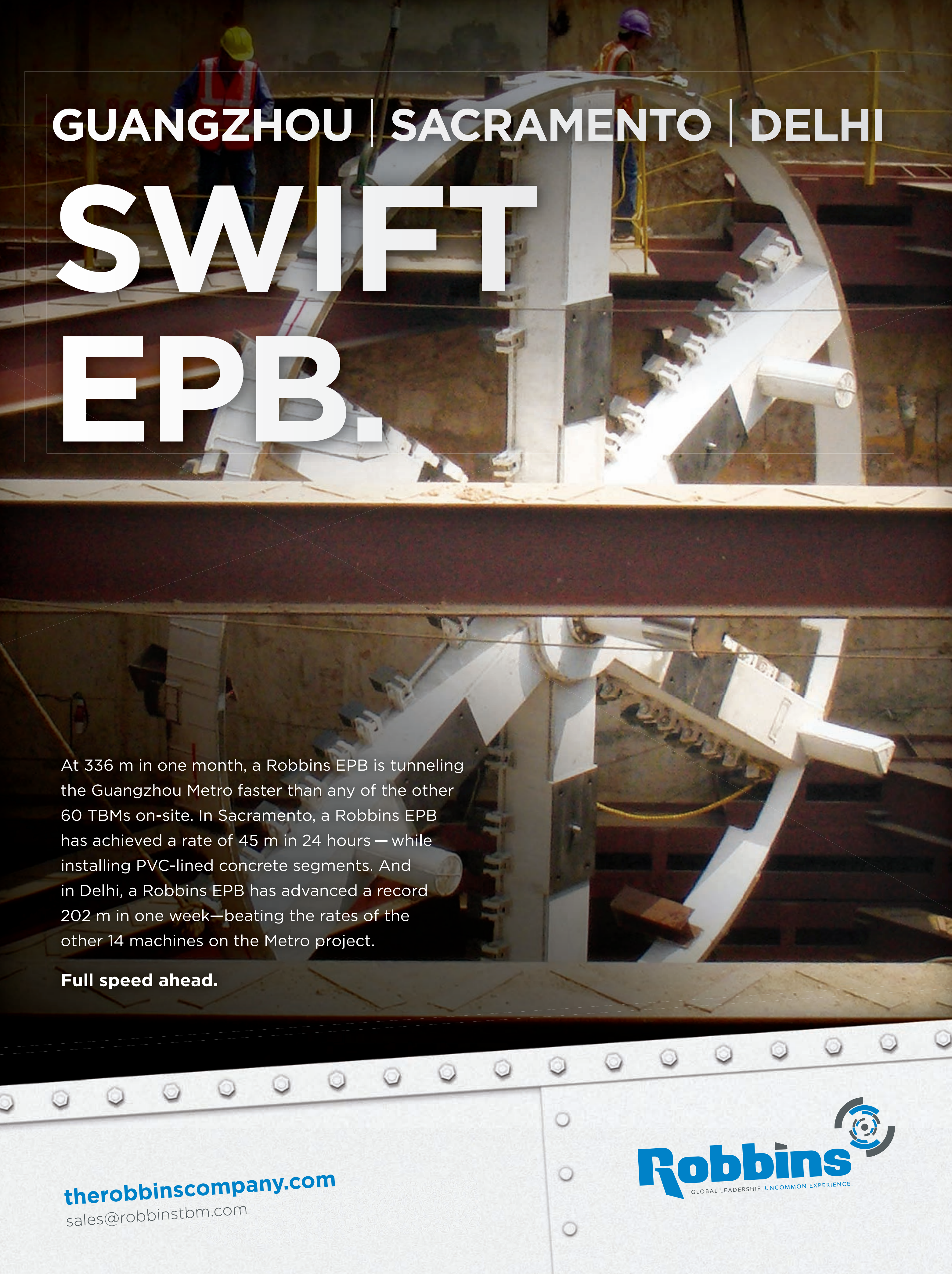
THE OFFICIAL PUBLICATION OF UCA OF SME WWW.TUCMAGAZINE.COM VOLUME 3 NO 3 SEPTEMBER 2009

Designing the Port of Miami tunnel project

Chinese hydropower tunnel project

Another successful RETC

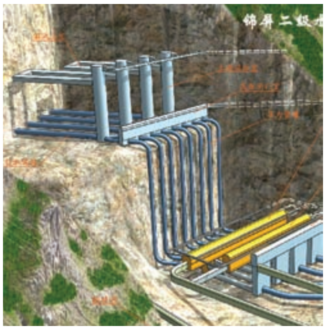
Special Editorial Section from the publisher of *Mining Engineering*


GUANGZHOU | SACRAMENTO | DELHI
SWIFT EPB.
At 336 m in one month, a Robbins EPB is tunneling the Guangzhou Metro faster than any of the other 60 TBMs on-site. In Sacramento, a Robbins EPB has achieved a rate of 45 m in 24 hours — while installing PVC-lined concrete segments. And in Delhi, a Robbins EPB has advanced a record 202 m in one week—beating the rates of the other 14 machines on the Metro project.
Full speed ahead.
therobbinscompany.com
sales@robbinstbm.com
Robbins
GLOBAL LEADERSHIP. UNCOMMON EXPERIENCE.

T&UC
TUNNELING & UNDERGROUND CONSTRUCTION
AN OFFICIAL PUBLICATION OF UCA OF SME WWW.UCA.SMENET.ORG VOLUME 3 NO 3 SEPTEMBER 2009
Special editorial section from the publisher of *Mining Engineering*

CONTENTS

FEATURE ARTICLES



COVER STORY

CONTENTS — This month's cover is one of the submissions for the UCA of SME Division's 2010 calendar. The Division is accepting submissions through Oct. 1. See page 38 for details. The photo is of a 1.9-km- (1.2-mile-) long tunnel, part of the Arroyo Drive Relief Sewer Project in Los Angeles, CA. Photo courtesy of Akkerman Inc.

DEPARTMENTS

Copyright 2009 by the Society for Mining, Metallurgy and Exploration, Inc. All rights reserved. TUNNELING & UNDERGROUND CONSTRUCTION (ISSN 0026–5187) is published quarterly by the Society for Mining, Metallurgy, and Exploration, Inc., at 8307 Shaffer Parkway, Littleton, CO, 80127–4102. 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, 8307 Shaffer Parkway, Littleton, CO, 80127–4102. Article copies and back issues available on microfilm or microfiche from Linda Hall Library in Kansas City, Mo. Printed by Cummings Printing Co.

CHAIRMAN'S COLUMN

Tunnel industry is still strong

On June 17, 2009, I had the honor of being handed the gavel for a two-year term as Chairman of the UCA of SME. I am looking forward to the challenges associated with the position. The tunnel industry is currently very strong compared with other segments of the construction industry. We all must work hard to maintain this continued industry vitality. The UCA of SME is an excellent vehicle to assist the tunnel industry by advancing a pro-growth agenda, being a forum for addressing technical issues that impact the industry, developing a scholarship program to assist young people to enter the industry, conducting the North American Tunneling (NAT) conference and specialty regional conferences to promote industry fellowship and knowledge, and other erstwhile activities.

Special recognition must be given to Brenda Bohlke for the work she did during her two-year term to advance the UCA organization and the tunnel industry. Brenda worked very hard to establish a UCA Scholarship Fund within the SME. She also worked closely with Bill Edgerton to establish the Education and Training Committee and create the Student Outreach Committee. Brenda ascends to the Past Chairman position in the organization and will continue to be involved in various UCA Executive Committee activities.

Tom Peyton's term as Past Chair of the UCA Executive Committee expired on June 17. But he will still be involved, as he has been nominated to be on the SME Board of Directors. His tenure as Chairman of the UCA was most demanding and his efforts are appreciated by the members. Tom's award as UCA Person of the Year in 2007 was earned and most deserved for his and Bob Pond's efforts in creating the UCA of SME in its current structure. Thanks to their efforts, I am pleased to report that the organization is now on a sound financial footing.

I want to welcome two new executive committee members to our organization, Robert Goodfellow, associate vice president/director of tunneling with Black & Veatch Corp., and Lester M. Bradshaw, Jr., president of the Bradshaw Construction Corp. I have known each of them for many years. Both are dedicated to advancing the industry and are not afraid to voice their opinions in industry discussion issues. We welcome their industry knowledge and the energy they bring to the organization. As he leaves the executive committee, I want to thank Richard Redmond for his contributions and service to the organization.

At the Rapid Excavation and Tunneling Conference luncheon in Las Vegas, NV on June 15, the UCA of SME gave its Lifetime Achievement Award to George Yoggy and its Person of the Year Award to Galyn "Rip" Rippentrop. Throughout my 30 plus years in the tunnel business, I have worked with each of these individuals on many tunnel projects and I must say that the awards are very deserving based on their contributions to the industry. Both individuals have worked hard to advance the project and were always very professional — except for Rip when a shipment was late — in their business dealings. One common attribute to George and Rip is that they took time to mentor the younger individuals under their management responsibilities, a trait that we must all adhere to advance the industry. Both individuals have proven that the industry does not have to use the old "sink or swim" approach to employee development.

As I travel across North America, I meet with many owners, de-

Continued on page 12

David R. Klug,
UCA of SME Chairman

Tunnel under San Francisco Bay to begin construction in 2010

With ominous warnings that a major earthquake will hit the San Francisco Bay area in the next 30 years, the San Francisco Public Utilities Commission (PUC) plans to act.

Bids for a 3.2-km- (5-mile-) long tunnel under the bay were advertised on July 31.

The tunnel is expected to include 2.7-m- (9-ft-) high steel pipe in a 4-m- (14-ft-) high corridor and will be run as deep as 31 m (103 ft) below the bay floor, the *San Jose Mercury News* reported.

There are about 12 companies in the world that are certified to perform the job, which is estimated to cost $347 million. Digging will start next spring on the Menlo Park shoreline just south of the Dumbarton Bridge, and head eastward, with work scheduled to be completed in 2015. An additional 26 km (16 miles) of pipe connecting to the tunnel on either side of the bay also will be replaced.

The job is part of a $4.5-billion renovation by the San Francisco PUC to upgrade its water system. Commonly known as the Hetch Hetchy System, the network of tunnels, pipes and reservoirs delivers water 269 km (167 miles) through gravity-fed pipes from Hetch Hetchy Reservoir in Yosemite National Park to Crystal Springs Reservoir along I-280 in San Mateo County.

The largest water system in the Bay Area, it provides some or all of the drinking water to 2.5 million people from North San Jose through the Peninsula to San Francisco, along with Fremont, Hayward and other parts of the East Bay.

Another agency, the Santa Clara Valley Water District, provides water to 1.8 million people in Santa Clara County from groundwater and the delta.

The Hetch Hetchy system was built following the 1906 earthquake, when San Francisco burned after its water system failed. Today, much of its equipment is in need of repair or replacement.

The tunnel will replace two large steel pipes built in 1925 and 1936 that sit on the floor of the bay, and could easily break in a major quake, cutting off water for weeks.

"Being buried deep in stronger, tighter materials, there is much smaller vulnerability to being pulled apart from shaking and liquefaction," David Schwartz, a geologist with the U.S. Geological Survey in Menlo Park, said of the proposed tunnel. "From an engineering point of view, it's much stronger."

Caltrans has retrofitted dozens of freeway overpasses and is rebuilding the Bay Bridge. Pacific Gas & Electric has upgraded gas lines and substations. BART is retrofitting the Transbay Tube, a 5.8-km-(3.6-mile)-long cylinder that sits on the floor of the bay, connecting Oakland and San Francisco.

USGS scientists say there is a 63 percent chance of a quake of 6.7 magnitude or larger hitting the Bay Area by 2036. Geologists are most concerned about the Hayward fault, which runs from San Jose to Richmond.

With that backdrop, the San Francisco PUC won approval from San Francisco voters in 2002 to upgrade its water system. Funding is coming from revenue bonds, financed by a near-doubling of residential water rates in San Francisco from $23 a month now to $40 in 2015, with similar hikes expected in other communities that receive Hetch Hetchy water.

The project also will rebuild pipelines, water treatment plants and Calaveras Dam, north of San Jose, over the next five years so that they can withstand a quake of up to magnitude 7.9 on the San Andreas fault and 6.9 on the Hayward fault.

Despite the sensitive politics of anything involving the bay, environmentalists did not oppose the new tunnel. ■

California water officials study building delta tunnel

State engineers in California are studying a proposal to send water supplies to southern California through a tunnel under the Sacramento - San Joaquin Delta, rather than through a peripheral canal, the *Associated Press* reported.

The Department of Water Resources is considering the tunnel option as part of a broader, long-term effort to lower pressure on the beleaguered estuary.

Proponents say routing water underground could help protect endangered fish species while securing supplies for San Joaquin Valley farmers and southern cities.

But opponents fear diverting water would turn the delta into a swamp.

By year's end, officials with the Bay Delta Conservation Plan are expected to release a draft conservation plan that could include options both above and below ground. ■

UtahAmerican tunneling up to coal seam

UtahAmerican Energy Inc., a subsidiary of Ohio-based Murray Energy Corp., is taking a unique approach to get at coal seams in a Utah mountain range — the company is tunneling up to the coal.

From the base of a 305-m (1,000-ft) cliff face, UtahAmerican Energy is constructing three tunnels. It has been working for nearly a year to dig 152 m (500 ft) of tunnels that will advance a total of 366 m (1,200 ft) into the Book Cliffs range, about 193 km (120 miles) southeast of Salt Lake City.

Tunneling upward to reach into a coal mine is unusual but reflects some of the more freakish geography of central Utah's mountainous coal belt, Dana Dean, Utah's associate director for mining told the *Associated Press*.

The hard-rock tunnels will allow UtahAmerican to recover coal without occupying Lila Canyon, a wild fold in the Book Cliffs that hides big game habitat and ancient rock art panels. The work is taking place about 8 km (5 miles) east of state Route 191, the nearest highway.

Three hard-rock tunnels — one for vehicle and equipment access, another for a conveyor belt to move coal, plus a third for ventilation — are being blasted out of sandstone.

Dean said the tunnels go horizontally into the cliff face for a short distance, then angle upward at a slope of up to 12 degrees.

The U.S. Bureau of Land Management (BLM) is calculating the value of an estimated 38.3 Mt (42.2 million st) of recoverable coal that UtahAmerican wants to buy at the Dry Canyon site, according to a notice published in the *Federal Register*.

With a sealed bid, UtahAmerican will offer a figure for what it believes the coal is worth, then pay one-fifth of that amount for mining rights if it emerges as the winner, BLM spokesman Mitch Snow said Monday.

After that, UtahAmerican will pay an annual rental fee of $3 an acre, plus royalties of 8 percent of the coal produced, he said. The federal royalties will be split with Utah. ■

Brightwater to open on schedule without finished tunnel

Work on the Brightwater sewage plant in King County, WA was halted when mechanical problems stalled both tunnel boring machines (TBM). However, project manager Gunars Sreibers said the plant will be put into operation in 2011, as scheduled.

The 21-km (13-mile) tunnel that was being bored by the TBM's will not be ready to carry the treated wastewater when the plant opens so it will be sent through existing pipes and dumped into the Puget Sound, the *Seattle Times* reported.

Sreibers said the county and the contractor operating the two stalled boring machines have not discussed who will bear the cost of the delay.

The rims of the cutter heads on the 5.3-m- (17.5-ft-) diameter Herrenknecht TBM slurry machines were damaged, allowing rock and boulders to get stuck. The general contractor, the joint venture Vinci/Parsons RCI/Frontier-Kemper, first stopped tunneling in May and laid off about 160 employees. The second machine was idled in June.

Vinci's $221-million contract includes two tunnel segments. Both the contractor and the manufacturer have recommended adding additional tools to the cutter heads to avoid future problems. There is about 45 m (150 ft) of water pressure on the machines, Sreibers said. The contractor is sinking dewatering wells 100 m (330 ft) to the front of the cutter heads to relieve some of the pressure and allow workers to perform repairs under normal atmospheric conditions.

Sreibers said the first machine is expected to go back into service in September or October, the second machine by late fall or early winter.

The $1.8-billion Brightwater plant, under construction on Highway 9 in Snohomish County north of Woodinville, was scheduled for completion in 2010 but the startup date was pushed back to September. ■

Black & Veatch to design McCook Reservoir tunnel

The engineering and design firm of Black & Veatch has been chosen by the U.S. Army Corps of Engineers (USACE) as the design engineer for the McCook Reservoir main tunnel. The new 550-m (1,800-ft) long bifurcated tunnel system will connect the future McCook Reservoir to Chicago's Deep Tunnel system. The tunnel is aimed at improving water quality in area rivers and Lake Michigan and reducing flood risk for the city of Chicago and suburban communities.

"We are pleased that Black & Veatch has engaged its top resources to execute this assignment," said Linda Sorn, USACE Chicago District Chief of Technical Services in a statement. "The McCook Reservoir is a marquee project for the USACE and our local sponsor, the Metropolitan Water Reclamation District (MWRDGC) of Greater Chicago, to reduce flood risk, protect the vital Lake Michigan water supply and improve the quality of water in area watercourses."

The project is a key component of Chicago's Tunnel and Reservoir Plan (TARP). Through TARP, MWRDGC collects and diverts combined sewer overflows and floodwaters throughout metropolitan Chicago to temporary holding reservoirs before treatment. When completed, the tunnel will connect Chicago's Mainstream Tunnel to the planned McCook Reservoir and bolster protection of the local water supply.

Computational fluid dynamics and finite-element numerical modeling will be used to address complex system hydraulics and geotechnical conditions, including steel and concrete lining design details.

Dan McCarthy, president and chief executive officer of Black & Veatch's global water business said, "the McCook Reservoir project will deliver sustainable benefits to Chicago's people, environment and economy."

A set of six high-head wheel gates will be installed 91 m (300 ft) below grade to control flows into and out of the McCook Reservoir.

Black & Veatch will prepare a geotechnical baseline report and assist in development of risk management strategies for design and constructability, in addition to sequencing and procurement of work, schedule and budget controls.

In addition to the main gates and connection tunnel system for McCook Reservoir, the global engineering, consulting and construction company is also leading the design for the ground water protection system and the Thorn Creek connection tunnel, and is leading the final preparations for the Thornton Composite Reservoir. The projected construction costs for all facilities Black & Veatch is designing in conjunction with TARP are estimated to be more than $500 million. ■

Drilling on Los Angeles' subway to the sea completed

Los Angeles, CA Mayor Antonio Villaraigosa said crews are nearly finished drilling 70 holes across the city's west side. This is the first step in building the long-awaited subway to the sea.

Villaraigosa said that crews had to dig up to 24 m (80 ft) into the ground to assess soil conditions before tunneling could start. He said the drilling marked the first step in a decade-long process to build a crucial subway line across the city to Santa Monica.

The project will provide about 16,000 construction jobs and promises to reduce traffic in one of the most congested areas of Los Angeles County.

The line is expected to cost between $6 billion and $9 billion, depending on whether a segment across West Hollywood is included. ■

Contract awarded to complete tunnels on Vancouver's Seymour-Capilano project

The Seymour-Capilano filtration project in Vancouver, British Columbia got back on track when Metro Vancouver awarded a contract to the Seymour-Cap Partnership to complete the twin tunnels component of the Seymour-Capilano filtration project.

The Seymour-Cap Partnership includes the companies Frontier-Kemper/J.F.Shea/Aecon.

The Seymour-Cap Partnership bid $181 million to complete the tunnels, and will proceed using the original engineering design and the two tunnel boring machines (TBM) currently in place. The project will provide filtration and ultraviolet disinfection of drinking water from two of Metro Vancouver's three source water supplies.

Earlier this year, it was reported that the price of the project could swell to as much at $820 million, up from the original 2003 estimate of $600-million.

The project has four key elements: the filtration plant, located in the Lower Seymour Conservation Reserve; the Capilano pumping station; twin tunnels that will convey water from the Capilano source to the plant for treatment and return treated water for distribution, and an energy recovery facility.

The filtration plant and energy recovery facility are nearing completion, and the pumping station is complete. Work on the twin tunnels was halted in January 2008 by Bilfinger-Berger Canada Inc., the original contractor. Citing unsafe working conditions, Bilfinger-Berger ceased work on the contract, which was terminated by the owner in May 2008.

Bilfinger claimed its crews had run into a fissure of loose rock that posed a serious danger to them, forcing them to a standstill with boring only about 60 percent complete. Metro Vancouver refuted the claim, saying its own consulting engineers had deemed the tunnels stable.

Metro Vancouver has filed suit to recover costs of completing the tunnels from Bilfinger-Berger.

Initially budgeted at $200 million, which included Bilfinger-Berger's $105 million contract for tunnel construction as well as engineering, tunnel liner and other associated expenditures, overall costs for the tunnels component are projected to double to $400 million.

Work on the tunnels was expected to commence in April, with completion anticipated at the end of 2012 or early 2013. Filtration plant construction is expected to be completed this spring and the plant fully operational by the fall. ■

Five Lovat machines begin work on tunnels for 2014 Olympic Games

A total of five Lovat tunnel boring machines (TBM) will be used to mine three service tunnels and two railway tunnels in preparation for the 2014 Winter Olympic Games to be held in Sochi, Russia.

The machines are owned and operated by the largest Russian tunneling contractor, OAO "Bamtonnelstroy" located in the city of Krasnoyarsk.

A number of tunnels will connect Adler, a town on the sea coast near Sochi in Russia, to the sites of the 2014 Winter Olympic Games located higher in the mountains. These tunnels are a significant part of infrastructure being built on the order of the Russian Federal Railways. These tunnels will grant visitors and participants access to the Olympic Games.

A total of five Lovat TBMs will be mining three service tunnels and two railway tunnels, a combined total length of 16.4 km (10 miles) for this notable project. ■

Land use application for ARC tunnel approved by New York City

Work on the $8.7-million Access to the Region's Core (ARC) Mass Transit Tunnel has been cleared to begin in Manhattan, NY later this year following the approval of the project's land use plan by the New York City Council on July 29.

Council members voted unanimously 47-0 to approve the massive passenger rail project's special permit application under the city's Uniform Land Use Review Procedure (ULURP).

"Today marks another step forward in the development of this monumental transportation infrastructure project that will provide enormous economic and environmental benefits for the entire region," said New Jersey Gov. Jon S. Corzine. The council's vote will allow tunnel work to be ongoing on both sides of the Hudson River by year's end.

In June, ground was broken in New Jersey. Overall, the project will create approximately 6,000 construction-related jobs annually. The Port Authority of New York and New Jersey and its partner, NJ Transit, are working to complete the tunnel by 2017. The Port Authority has committed $3 billion to the project. Agency officials voluntarily submitted the project for review by city representatives under the land-use process, seeking to encourage public participation and community support for the initiative.

The land use vote was the culmination of an extensive process to work with the City Planning Commission, Manhattan Borough President Scott Stringer, City Council Speaker Christine Quinn, city community boards and other local stakeholders on the project's design and plans.

The ARC Mass Transit Tunnel will double commuter capacity between New Jersey and Midtown Manhattan, allowing a maximum of 48 trains per hour compared with 23 now through the existing, 100-year-old, two-track tunnel. The project is designed to help keep the region economically competitive during the 21st century. The work in Manhattan will include an expansion of Penn Station under 34th Street and provide underground connections for the first time to the Sixth Avenue subway lines.

"We appreciate the City Council's overwhelming endorsement of the ARC Mass Transit Tunnel," said Anthony Coscia, the Port Authority's chairman. "This strong support for our generation's equivalent of the George Washington Bridge will help support our region's economic prosperity for generations to come." ■

Single track considered in Maryland

A single-track tunnel under Cooks Lane is being considered by the Maryland Transit Administration (MTA) for the Red Line. The proposal would require east- and westbound light rail trains to share one track through a 1.6-km- (1-mile-) long tunnel. The plan might save $60 million but could pose operating difficulties and raise safety concerns, the *Baltimore Sun* reported.

A single-track tunnel is intended to reduce the Red Line's cost and bring it within federal funding guidelines. Without such cost cuts, the entire project from Woodlawn to Bayview could collapse.

"Single-tracking" is a phrase that leaves a sour taste in the mouths of Baltimore-area transit riders. Much of the existing Central Light Rail Line was originally built as a single-tracked line, but trip delays and other service problems forced an eventual retrofitting project that involved extended service shutdowns.

The Federal Transit Administration imposes a rigid formula of cost-effectiveness for funding of construction of local transit projects. Projects above a certain threshold will not be considered.

The plan preferred by the city administration, known as Alternative 4C, has been estimated to cost $31 million under that formula.

Under 4C, the MTA would build a light rail line that would operate in one tunnel under downtown, Harbor East and Fells Point and another under Cooks Lane. ■

Second phase of New Delhi Metro Line completed

Construction of the second phase of operations on the largest tunnel in any urban city in India, the 2.85-km (1.7-mile) Airport Express Rail tunnel under New Delhi, was completed by Delhi Metro Rail Corp. (DMRC) on Aug. 19.

The New Austrian Tunneling Method (NATM) was used in order to preserve the rare and diverse flora and fauna of the protected forest above the tunnel that runs from Talkatora to Buddha Jayanti Park. With this tunnel breakthrough, only 2 km (1.2 miles) of tunneling is left to be completed for Phase II, in which 35 km (22 miles) of the metro is underground.

The alignment of the Metro line for the Airport Express Line goes under the Central Ridge, which has several rare species of trees and animals. To ensure these are preserved, DMRC decided to adopt the NATM method in which a tunnel is constructed by controlled blasting under the earth's surface.

Construction of the tunnel began in December 2007, when three access shafts were dug up, one each at the start and end of the tunnel and one in the middle.

Controlled explosions were carried out at several locations to break the rock and the pieces taken out through the shafts. Once the muck was cleared, the tunnel was given a concrete lining. The process was extremely challenging for DMRC as soil conditions were mixed and unknown, and all through the process, the ridge could not be disturbed. To ensure safety and keep the earth from caving in, engineers moved slowly and created just about 1.5 m (5 ft) of the tunnel daily. All through construction, equipment such as 3D targets, extensometers and inclinometers were used to monitor settlements.

The other option available was the cut-and-cover technique, but that would have required clearing the entire surface over the tunnel alignment to dig and create it. This would have destroyed the forest. Due to time constraints, a tunnel boring machine could not have been used either because the tunnel had to be created in a record two years, in time for the Commonwealth Games.

Unlike other underground Delhi Metro lines which have two tunnels, one for the train running in either direction, here, there is a single oval-shaped bore in which both the Metro tracks will be laid after creating a central wall for track separation. This large bore makes it the largest tunnel created in any urban city in India.

Delhi Metro's Phase II spans across 125 km (77 miles), of which 35 km (22 miles) is underground. DMRC used three techniques for underground stretches, tunnel boring machines, NATM and the traditional cut-and-cover method. Now, only five drives by TBMs remain to cover about 1.3 km (0.8 mile), of which 675 m (2,220 ft) is on the Central Secretariat-Badarpur line and 600 m (2,000 ft) on the Airport Express Line. Besides this, about 550 m (1,800 ft) to be constructed by cut-and-cover method remains on the Airport Express Line. ■

Overland Park chooses tunneling option to save trees

Officials of the Johnson County (KS) Wastewater District agreed to underground tunneling methods to save thousands of trees in the Overland Park Arboretum and Botanical Gardens.

The sewer line will run through a heavily forested area of the arboretum and the tunneling method will cost about $1 million more than a cut-and-cover method.

Karen Kerkhoff, arboretum supervisor, said the usual trenching method would have cleared a path 31 m (100 ft) wide through the heavily wooded area and would have destroyed thousands of trees.

That idea was eventually discarded in favor of a 1,000-m (3,330-ft) tunnel under the arboretum. A tunnel-boring machine (TBM) will excavate a 2.2-m (88-in.) tunnel as far as 19 m (63 ft) under the ground. The arboretum was visited by 104,000 people last year.

The tunneling is part of an $18-million project to ultimately bring sewers to a 65-km^2 (25-sq mile) area of southern Johnson County.

The tunnel will cost $5.9 million or about $1 million more than the trenching option and will take about 104 days to complete, according to Timothy M. Schneller, an engineer with GBA Architects and Engineers in Lenexa.

Money for the project comes from a wastewater fund that receives its dollars from a fee included on Johnson County property tax bills. ■

CHAIRMAN'S COLUMN

Continued from page 4

engineers, contractors, subcontractors and specialty suppliers. I have found that they all share the same common problem, the availability of trained engineers and technicians. We are all aware of the shortage of degreed civil engineers. The heavy construction industry currently has difficulty filling those positions. And, due to the specialized nature of the tunnel industry, we are having more difficulty finding young engineers wanting to enter the industry. The recession may help ease this problem, but that is not a long-term solution.

There is one industry staffing problem that many people may not be aware of and that is the need for trained electricians, mechanics and welders. I have found this to be more of a problem than the shortage of degreed engineers because equipment is becoming more complicated and the maintenance people are growing older.

The UCA of SME has established a Scholarship Committee to help address future industry recruitment and staffing problems. I encourage individuals and companies to make a contribution to the UCA Scholarship Fund, as this is money well invested in the future of the tunneling industry. Contact Mary O'Shea at the UCA of SME (phone 303-948-4211, e-mail oshea@smenet.org). The UCA Scholarship Fund is not limited to four-year civil engineering degrees. It is based on need and the desires of the individual, so please contact us with a scholarship fund contribution or to request a scholarship application form.

I am often asked if I believe the economic stimulus package is benefiting the tunnel industry. We have observed that some of the major transportation projects in major urban areas — the MTA projects in New York City, the Trans Hudson Express (THE) program in New Jersey, the Caltrans Caldecott Fourth Bore tunnel in Oakland, CA, and the Sound Transit University Link project in Seattle, WA — have received additional funding to advance the program. The program was designed to initiate "shovel ready" projects, such as those in the water and sewer industry. But, contrary to what was promised, I have seen minimal benefit from the stimulus package to this industry. The benefit of the stimulus may not occur until 2010 or later.

Prior to the economic stimulus package, the industry was and continues to be strong, as major tunnel programs are currently under way. Among them are the THE program in New York-New Jersey, the MTA Second Ave. and East Side Access programs in New York City, the WASA CSO tunnel program in Washington, D.C., the SFPUC water tunnels in San Francisco, CA, the Sound Transit University Link projects and the Washington DOT Alaskan Way project in Seattle, WA. And major tunnel programs are under way in Canada for the York Region and the Toronto Transit Commission. For additional details, refer to the UCA Tunnel Demand Forecast in this issue of *T&UC*. It is also available online to UCA members at www.tucmagazine.com.

I look forward to communicating with you in future reports. Please e-mail me if you have questions regarding the UCA or if there are issues you want the Executive Committee to evaluate. If you or your company are not members of the UCA of SME, I encourage you to join. ■

UCA calls for award nominations

The Underground Construction Association (UCA), a division of SME, will present the UCA awards at the 2010 North American Tunneling Conference (NAT) in Portland, OR. The awards to be presented are: Outstanding Individual, Project of the Year, Outstanding Educator and the Lifetime Achievement Award. The nominations for the awards will be reviewed and the winners selected by the UCA Executive Committee at its January meeting. The recipients' photos and biographies will appear in the March issue of *T&UC*. Guidelines and nomination forms are available on the UCA of SME Web site, uca.smenet.org. Please submit your nominations by Jan. 5, 2010 to Mary O'Shea at oshea@smenet.org. ■

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Hudson River Crossing	NJ Transit Board THE Program	Newark	NJ	Subway	8,000 x 2	24.5	2010	Under design
Palisades Tunnel	NJ Transit Board THE Program	Newark	NJ	Subway	5,400 x 2	24.5	2009	Bid date Dec. 2, 2009
Manhattan Tunnel	NJ Transit Board THE Program	New York	NY	Subway	6,000 x 2	24.5	2009	Bid date Sept. 22, 2009
THE 34th St. Cavern & Station	NJ Transit Board THE Program	New York	NY	Subway	2,200	100 x 100	2010	Under design
Second Ave. Subway Tunnels	NYC-MTA	New York	NY	Subway	2,200	30,000	2014	Under design
ESA Queens Tunnel	NYC-MTA	New York	NY	Subway	10,500	20	2008	Awarded Granite/ Traylor/ FKCI JV
Water Tunnel #3	NYC-DEP	New York	NY	Water	24,000	20	2012	Under design
Harbor Siphons Tunnel	NYC-DEP	New York	NY	Water	10,000	10	2009	Advertising late 2009
Cross Harbor Freight Tunnel	NYC Regional Development Auth.	New York	NY	Highway	25,000	30	2013	Under design
Cross Sound Link Highway Tunnels	Sound Link	Long Island	NY	Highway	190,000	55	2014	Under design
Cross Sound Link Service Tunnel	Sound Link	Long Island	NY	Highway	95,000	38	2014	Under design
East Side Water Supply Project	Monroe County Water Authority	Rochester	NY	Water	6,500	8	2009	Advertising 4th Q 2009
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2011	Under design
Near Surface Interceptors	Narragansett Bay Commission	Providence	RI	Sewer	19,500	3-6	2011	Preliminary design
Bi-County Water Tunnel	Washington Sub. San. Commission (WSSC)	Laurel	MD	Water	28,000	10-12	2009	Awarded to Renda JV
East-West Subway Extension	Baltimore MTA	Baltimore	MD	Subway	32,000	18	2012	Under design
Corvalis to Fox Mill Water Main	Fairfax County Water Authority	Fairfax	VA	Water	8,600	8	2009	Kassouf Co. Low bidder
WASA CSO Program Blue Plains tunnel Anacosita River tunnel Northeast Branch tunnel Northeast Boundry tunnel	DC Water and Sewer Authority	Washington	DC	CSO CSO CSO CSO	23,400 12,500 11,300 17,500	23 23 15 23	2011 2013 2018 2021	Under design Under design Under design Under design
Market St. Drainage Improvements	City of Charleston	Charleston	SC	Sewer	3,000	10	2010	Under design
South River Tunnel	City of Atlanta	Atlanta	GA	CSO	9,000	14	2008	Awarded to Gilbert Southern

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

FORECAST T&UC

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
North/South River Tunnel	Georgia DOT	Atlanta	GA	Highway	77,000	41	2015	Under design
Snapfinger Interplant CSO Tunnel	Dekalb County	Decatur	GA	CSO	26,400	28	2010	Under design
Port of Miami Tunnel	Florida DOT	Miami	FL	Highway	7,400	39	2011	Awaiting funding
Sewer replacement	Miami Dade	Miami	FL	Sewer		5	2010	Under design
Lockbourne Interceptor Sys. Tunnel	City of Columbus	Columbus	OH	Sewer	10,000	12	2012	Under design
OSIS Aug. & Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	25,300	18	2010	Under design
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2012	Under design
Alum Creek Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	74,000	10 to 18	2014	Under design
Black Lick Tunnel	City of Columbus	Columbus	OH	Sewer	32,000	8	2013	Under design
Austin Downtown Tunnel Project	City of Austin	Austin	TX	Sewage	18,600	10	2009	Bid date Oct. 1, 2009
Water Treatment Plant #4	City of Austin	Austin	TX	Water intake	15,000	7 to 9	2010	Under design
Waller Creek Tunnel	City of Austin	Austin	TX	CSO	5,300	22	2010	Under design
Thornton Connecting Tunnels Project	Metro Water Reclamation District	Chicago	IL	CSO	1,300	30	2009	Bid date Sept. 15, 2009
County Grounds Tunnel	Milwaukee MSD	Milwaukee	WI	Flood management	2,700	17	2008	Awarded to Shay/Kenny JV
Belmont - Southport Plant Connection	City of Indianapolis DPW	Indianapolis	IN	CSO	29,000	12	2010	Under design
Pogues Run Tunnel	City of Indianapolis DPW	Indianapolis	IN	CSO	11,000	18	2013	Under design
Drumanard Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200 x 2	35	2010	Under design
Drumanard Tunnel - Pilot Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200	12 x 12	2009	Under funding review
River Mtn. Tunnel # 3	Clean Water Coalition	Las Vegas	NV	Wastewater	44,000	15	2012	Under design
CWC Reach 3	Clean Water Coalition	Las Vegas	NV	Wastewater	7,500	15	2012	Under design
Univ. Link Light Rail Extension Univ. Link Tunnel U220 Univ. Link Tunnel U230	Sound Transit	Seattle	WA	Subway Subway	22,800 3,800 x 2	19 19	2009 2009	Awarded to Traylor/FKCI; Bid date 8/26/09
Alaskan Way Highway Tunnel	Washington DOT	Seattle	WA	Highway	10,500	54	2011	Under design
Caldecott 4th Bore	CALTRANS	San Francisco	CA	Highway	5,000	50	2009	Bid date Sept. 16, 2009
Third Ave. Subway Tunnel	S.F. Muni Metro	San Francisco	CA	Subway	10,000	20	2011	Under design

FEATURE ARTICLE

Caterpillar with tunnel boom boosts productivity on Swiss project

A dedicated tunnel construction version of the Caterpillar 328D LCR compact radius excavator is proving highly productive on the A9 Autoroute construction project near Visp, in Switzerland. It is the first machine of its kind to operate on a Swiss contract and uses a special dedicated front attachment designed and constructed by German Caterpillar dealer Zeppelin.

The machine offers a powerful, stable and compact solution for tunneling contractors. A rear overhang of just 305 mm (12 in.) provides a tail swing radius of just 1.9 m (6.2 ft). The 328D LCR is ideal for the restricted working areas within a tunnel construction site. The machine is equipped with the wide tracks from the 330D L conventional crawler excavator, ensuring maximum stability when operating.

In addition, the boom mounting has been moved further toward the center of the machine for the tunnel model, creating an increased lift capacity over the front end compared with a standard 325D L.

Caterpillar 328D LCR with tunnel boom at work.

The boom itself features a robust box section construction, with high-strength steels, additional supporting struts and reinforced bearings for maximum durability. All pins have hard-chromium plating for optimum protection against wear. Stick digging force is a powerful 134 kN, with up to 212 kN of bucket digging force available, for maximum penetration in blasted material.

The 328D LCR is also equipped with a heavy-duty dozer blade as standard. This ensures outstanding stability when working and providing a useful secondary tool for clearing and leveling within the jobsite.

Two 45° tilting mechanisms in the boom construction, allow the boom to be swung to 45° on either side of the machine. So the specially designed attachment linkage provides increased rollback for access to the roof of the tunnel. A Caterpillar CW45S mechanical quick-coupler allows rapid changes between specialist tunneling attachments, standard Caterpillar buckets and a range of Caterpillar work tools.

The machine is powered by a Caterpillar C7 diesel engine. This six-cylinder EU Stage IIIA diesel motor offers 8 percent more power than its predecessor, with 140 kW (190 hp) available at just 1,800 rpm. Caterpillar's ACERT combustion technology results in lower fuel consumption and reduced exhaust emissions. However, the tunnel machine is also equipped with a diesel particulate filter as standard, to further cut exhaust gases within the tunnel working.

The 328D LCR is designed for use in transport tunnels of 6.8 m (22.3 ft) in height. With the tunneling boom in place, the machine has an operating weight of 42,540 kg (93,783 lbs), yet retains a transport height with the tunnel boom of just 3.9 m (12.8 ft). Transport width with 600 mm (23.6 in.) track shoes, is just 3.2 m (10.5 ft).

On the A9 tunnel contract, the machine is being used by a consortium of Swiss and Austrian companies working for the canton of Valais' Routes Nationals Construction (RNC) department. The 31.8-km (19.7-mile) A9 Autoroute construction project will connect Sierre in the west and the town of Brig to the east. The tunnel that is bypassing the town of Visp is just one of a number along the mountainous route.

A fleet of Caterpillar machinery, including the 325D and 329D along with a couple of 308 excavators are at work in the two 3.4-km (2.1-mile) tunnel tubes. The 328D LCR is then brought in to finish off the tunnel profile, its compact dimensions and powerful performance providing the ideal combination for the complex task. The machine is being used with hydraulic breakers and buckets to remove the last of the material as the tunnel profile is formed.

Caterpillar dealer Zeppelin developed the tunnel boom specifically for use on the reduced tail swing 328D, originally ordering a number of base machines without booms from the Caterpillar factory. Caterpillar dealers outside of Germany can now order the boom structure directly from Zeppelin, to install onto the 328D upper structure. The excavator can also be equipped with a choice of tunneling boom and stick or with face shovel work equipment, adding to the versatility of this high performance model.

Tunnel construction is a complex and difficult application for any excavator. Until now, contractors have had little choice in the market, but with the arrival of the 328D LCR, tunnel projects have a machine that has been designed specifically to complete the task. With powerful breakout forces, compact dimensions and a stable working platform, the 328D LCR with tunnel boom is a productive addition to any contractor's equipment fleet. Zeppelin is also offering a modified 321D LCR excavator with a specific tunneling arrangement. In addition, Avesco, the Swiss Cat dealer, has developed a tunneling version of the 308 excavator with a swing boom for smaller tunnels. ■

Robbins TBM completes tunnel section in Australia

Heavy seasonal rains in Melbourne, Australia can create the potential for hazardous wastewater overflows. Protecting the area's valuable streams and rivers is the top priority of the city's five-year Northern Sewerage Project (NSP). Split into two stages, the NSP involves the construction of several new sewer tunnels, located deep beneath Melbourne's densely populated northern suburbs. Each of the seven new tunnels is being constructed with tunnel boring machines (TBM). In July, a 3-m- (9.8-ft-) diameter Robbins double shield TBM completed its first section of tunnel. The machine was launched to bore sections of Stage 2 during the first quarter of 2009.

The Robbins machine, which is being operated by local contractor John Holland, recently completed the 2.1-km- (1.3-mile-) long tunnel drive from Newlands Road to Jukes Road. Following a short maintenance break, the machine was set to continue tunneling a further 1.1 km (0.68 mile) north to L.E. Cotchin Reserve, where the pipeline will connect with an existing sewer system. Drill-and-blast as well as earth pressure balance (EPB) tunneling operations are also under way, making a total 4.5 km (2.8 miles) of new tunnels on Stage 2 of the project.

The John Holland crew stand proudly in front of the 3-m- (9.8-ft-) diameter Robbins double shield. Photo courtesy of John Holland Group.

Though both drill-and-blast and TBMs are being used, John Holland and client Yarra Valley Water opted for TBMs on the majority of the sections because of the higher potential advance rates, as well as reduced disturbance in urban areas. "Drill-and-blast operations are limited to the day shift only (7:00 a.m. to 5:30 p.m.), whereas TBMs allow for 24-hour operations, even in built-up residential areas," said Dave Kristy, community relations officer for the John Holland Group.

The TBM was launched from a shaft at Newlands Road, near to residential homes, requiring acoustic noise mitigation, including full sound-dampening enclosures for the three 24-hour construction sites located across the project. John Holland has also installed 2.4-m- (7.9-ft-) high hoardings around all shaft sites. The Robbins machine has tunneled beneath hundreds of residential properties without registering any concerns from the residents above.

Geology along the alignment has varied from massive columnar basalt to a mixed face of weathered basalt with infilled clay seams. Roof conditions have thus far remained competent enough to allow installation of the split set rock bolts originally designed for the tunnel.

Melbourne's NSP is part of the Victorian state government's Yarra River Action Plan. Once completed, it will provide new sewers for planned urban development in Melbourne's northern growth corridor. The wastewater system will help protect two local creeks from the damaging impact of sewage overflows after heavy rains, and ensure the prolonged health of the city's iconic Yarra River. The project spans more than 12.5 km (7.76 miles) of tunnels jointly delivered by Melbourne Water (Stage 1) and Yarra Valley Water (Stage 2). The project is scheduled for completion in mid-2012. ■

FEATURE ARTICLE

Port of Miami tunnel tender design and update

The Florida Department of Transportation District 6 (FDOT D6) began a study in 1987 for a master plan to improve the traffic circulation and congestions between the Port of Miami (POM) and downtown Miami, FL. This study included a tunnel connection between two man-made islands, the Watson and the Dodge islands. Though a finding of no significant impact (FONSI) was completed in 1992, the project remained on hold for about 10 years. In 2002, Florida Turnpike took over this project, re-evaluated its benefits to the local communities, determined its feasibility (specifically the tunnel options) and established a probable cost.

In 2005, the FDOT D6 regained its charge over the project and concluded that a bored tunnel under Biscayne Bay is feasible. Its primary components are:

- Widening of the MacArthur Causeway Bridge, to accommodate truck traffic to the Port of Miami.
- A tunnel connection between Watson Island and Dodge Island, where the POM is located.
- Connections to the POM roadway system, either for the traffic from the city of Miami or for the truck traffic from I-395 to the POM.

The project will improve access to and from the POM and provide a dedicated roadway connector linking the POM with the MacArthur Causeway (State Route 41/1) and I-395, specifically for the trucks in and out of the POM without going through downtown Miami. As identified in the project information memorandum (PIM), its primary objectives are to:

- Improve access to the POM, helping to keep it competitive and ensuring its ability to handle projected growth in its cruise and cargo operations.
- Improve traffic safety in downtown Miami by removing POM traffic, trucks and buses from the congested downtown street network and, in doing so, facilitate ongoing and future development plans in and around downtown Miami.

Wern-ping (Nick) Chen

Wern-ping (Nick) Chen, member SME, is vice president/tunnel design principal with Jacobs Engineering, e-mail nick.chen@jacobs.com.

FIG. 1

Project location plan and alignment.

Project location plan and alignment

The Port of Miami tunnel (POMT) project is located adjacent and east to downtown Miami. Its alignment extends from MacArthur Causeway Bridge, Watson Island, under the Cruise Channel in Biscayne Bay and to Dodge Island, where the POM is located. Its schematic project location plan and alignment is shown on Fig. 1.

Miami Tunnel Access (MAT) concession team

The MAT consists of the contractor, Bouygues Travaux Publics of France; the investment bank Babcock & Brown of Australia (in 2006 to 2008); the tunnel operation and maintenance controller, Transfield Services of Australia, and the design engineer, Jacobs Engineering with its subconsultant Langan Engineering and Environmental Services, Miami. Contractually, the design team is a subconsultant to the contractor Bouygues. In 2009, the financial sponsor of the MAT team has been altered from Babcock &Brown to Meridiam of France.

FIG. 2

Typical rock along tunnel alignment.

Opinion and interpretation presented in this paper are sole perspectives from the author, who was the tunnel design manager of Jacobs Engineering during tender design phase. They are neither official views from FDOT nor the MAT team.

Project funding and financing

The POMT is the first U.S. underground project to use the public-private partnership (PPP) project delivery model. It is being undertaken in cooperation with FDOT, Miami-Dade County, MDC, the Port of Miami (a Department of MDC), the city of Miami and other local stakeholders. The funding source is jointly by the FDOT, $457 million, MDC, $402.5 million, and the city, $50 million cash, $5 million in right-of-way on Watson Island. A concession team, the concessionaire, is selected by FDOT as the best value proposer and then enters into the concession with the FDOT. The concessionaire is responsible for the finance/design/build/operation/maintenance of the facilities, (operations/maintenance only for the tunnel portion) for a concession period of 35 years.

In accordance with FDOT, the primary objectives for pursuing the project as a PPP are to:

- Achieve the most efficient possible design, construction and maintenance of the project.
- Receive a high-level of quality, availability, upkeep, safety and user service.
- Share risks with private partners that is experienced in mitigating such risks.
- Agree to a long-term, guaranteed cost structure for the project.
- Facilitate a predictable and efficient implementation process.

Milestone payments

During construction, the concessionaire is responsible for privately financing the project and will receive milestone payments, $100 million, upon completion of the associated works:

- $20 million — completion of the tunnel designs, excluding mechanical, electrical and plumbing components.
- $40 million — tunnel boring machine (TBM) is at work in the first bore.
- $25 million — TBM is at work in the second bore, but in no event prior to completion of the first bore.
- $15 million — substantial completion of construction work on MacArthur Causeway.

In addition, the FDOT and its funding partners will provide approximately $300 million in "construction milestone payments" at the completion of the construction.

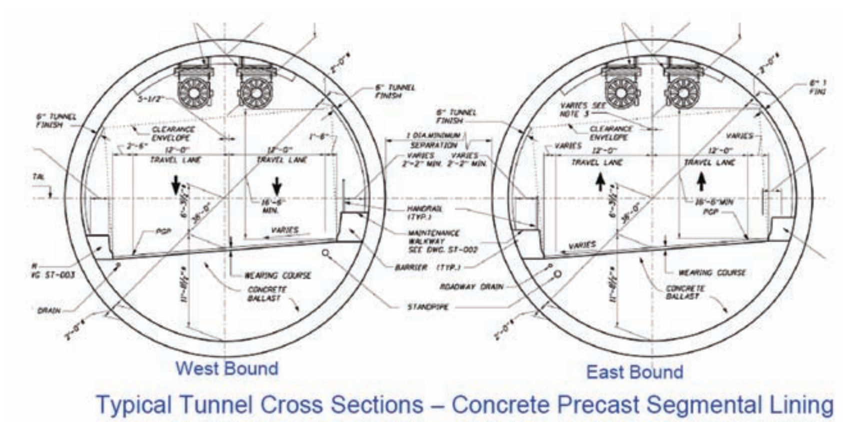
Changed geotechnical conditions payment

A $180-million geotechnical contingency fund was created to mitigate extra work costs and delay costs arising out of changed geotechnical conditions during construction. Its mechanisms are:

- The first $10 million — borne solely by concessionaire.
- The next $150 million — borne solely by the FDOT.

FIG. 3

Tunnel cross sections.



Designed by:	Tunnel Outside Diameter (OD)
FDOT	40-ft
MAT	41-ft

Table 1

Typical geotechnical parameters — Miami Limestone and Fort Thompson formation.

Parameters	Miami Limestone	Fort Thompson formation
Low to median RQD	0 to 5%	8 to 14%
Low UCS	No test	0.1 to 35 Mpa (40 to 5,000 psi)
High permeability	1.0 E-1 cm/sec baseline; locally can be 1 cm/sec	

- The last $20 million — borne solely by concessionaire.

Extra work costs and delay costs for changed geotechnical conditions that exceed $180 million are deemed extraordinary geotechnical losses.

Maximum availability payments

After the concessionaire's completion of construction and the commencement of operations, the FDOT will begin making periodic payments to the concessionaire. These "availability payments" will be based on the availability of the below-grade portions of the project, the tunnel, to provide vehicular access to the POM as well as the concessionaire's conformance with other criteria established in the request for proposal (RFP).

Regional geology

The following geological, hydrogeological and geotechnical information are excerpted from the geotechnical baseline report (GBR) developed by Parsons Brinckerhoff in 2006 for this project. Detail regional geology adjacent to the project site and subsurface exploration programs are addressed in the GBR and are not to be repeated here.

The topography in the area of Biscayne Bay is flat lying, varying in elevation from approximately 1.5 to 4.3 m (5 to 14 ft) above Mean Sea Level (MSL), based on National Geodetic Vertical Datum (NGVD), except for the ship channel area.

Along the proposed tunnel alignment, only the Miami Limestone and the Fort Thompson formations, interfingered with the Anastasia and Key Largo formations, are expected to be encountered by the planned tunnel construction, with the exception of the recent sediments and man-made fill overlying the bedrock formations as a thin veneer. Typically, this thin veneer is with mostly dredge-placed fill composed of very loose sand and lime-rock overlying naturally occurring, loose silty fine sand to sandy silt. The Miami Limestone is very porous and permeable due to the dissolution of carbonate by ground water migration. The Fort Thompson

Table 2

MAT vs. FDOT geological layers.

MAT layer #	MAT designation	FDOT designation	Ground properties – MAT interpretation
1	Fill	Fill	Sand and gravel.
2	Compressible silty sand		Soft plastic cohesive soil.
3	Miami Limestone	Miami Limestone	Limestone – soft rock, very weakly cemented (soil type behavior); low porosity; fairly consistent.
4	Sandy transition	Sandy transition	Sand with limestone – highly permeable soil like behavior with inclusions and interbedded zoned of limestone.
5	Upper Fort		Limestone with some sand – porous soft rock with sand zones.
		Fort Thompson formation	
6	Fort Thompson rock		6- a: Cemented sand/shell, with some sand – very porous rock with sand, well cemented. 6b: Cemented sand/shell – very porous, well cemented, consistent rock.
7	Loose to medium sand		Sand with inclusion and interbedded zones of sand stone – can be present 1) very loose soil, 2) potentially voildy condition, 3) vuggy soil filled zones and 4) isolated zones of hard rock
8	Key Largo formation		Sandstone, interbedded with sand lenses, zones, seam and occasional sand/silty sand pocket – very porous, well cemented, interbedded soft rock with sand.

formation underlies the Miami Limestone formation, generally containing alternating units of sands, marls, shells and sandy fossiliferous limestones. The GBR has been assumed to be at elevation -12 m (-40 ft). Furthermore, the Key Largo and Anastasia formations are interfingered within the Fort Thompson formation. Some representative geotechnical parameters of the Miami Limestone and Fort Thompson formation are listed in Table 1.

The high porosity of the ground to be encountered can be illustrated by a typical high quality Fort Thompson rock sample shown in Fig. 2.

In general, ground water elevations were measured between 0.6 and 1.5 m (2 and 5 ft) NGVD with extreme measurements of -0.3 and +1.68 m (-1 and +5.5 ft).

FIG. 4

FDOT profile and tunnel components.

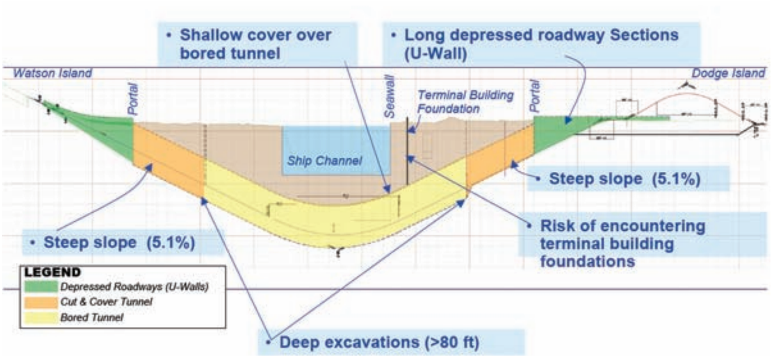
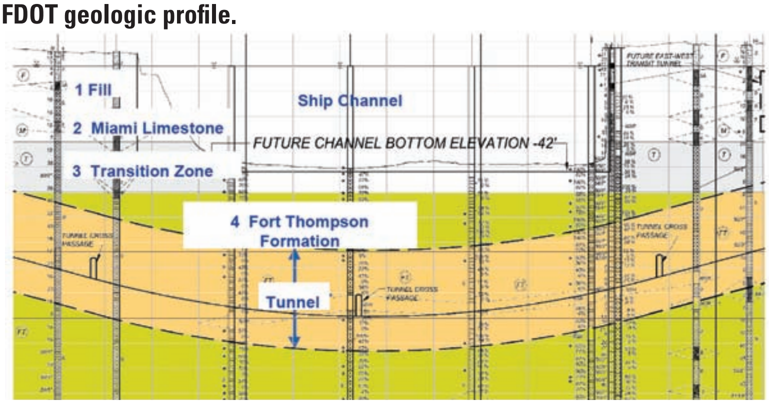


FIG. 5

FDOT geologic profile.



FDOT indicative designs

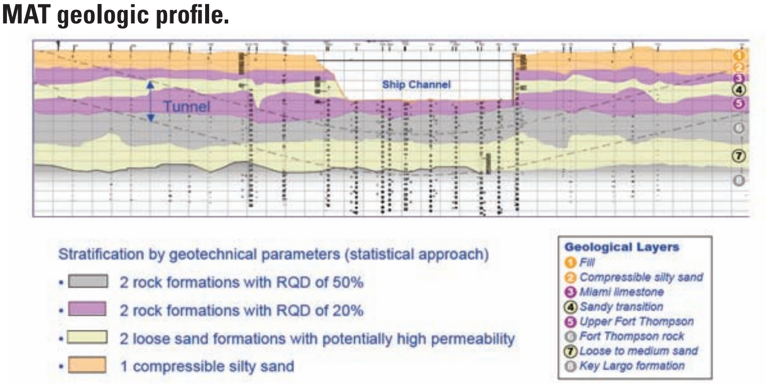
The proposed tunnel is an 11-m- (36-ft-) inside diameter, twin-bored, two-lanes each, highway tunnel to be excavated by a closed face earth pressure balance machine (EPBM) or a slurry shield machine. Its lining is a 61-cm- (2-ft-) thick bolted and gasketed precast concrete segmental lining. Figure 3 shows the FDOT indicative tunnel cross section. The determination factor for the size of the tunnel cross section is a functional requirement to satisfy the vehicular clearance, the space for tunnel ventilation system, the width of the walkway and life/safety issues, the tunnel stability, the buoyancy and the security reason.

The vertical tunnel alignment of the proposed tunnel is limited by the accesses on both sides of the two man-made islands, the Watson Island and the Dodge Island, the maximum grade to meet the current highway tunnel industry standard, the tunnel clearance to the bottom of the future ship channel deepening and the man-made obstructions, such as pile foundations. Figure 4 shows the FDOT indicative vertical tunnel alignment.

To facilitate tunnel design, bases for bidding purpose and basis for differencing site condition (DSC), the GBR provides a geological profile baseline along the indicative tunnel alignment. It divides the geological profile in to four primary zones: fill, Miami Limestone, Transition Zone and Fort Thompson formation in an order from top to bottom, as illustrated in Fig. 5.

FIG. 6

MAT geologic profile.

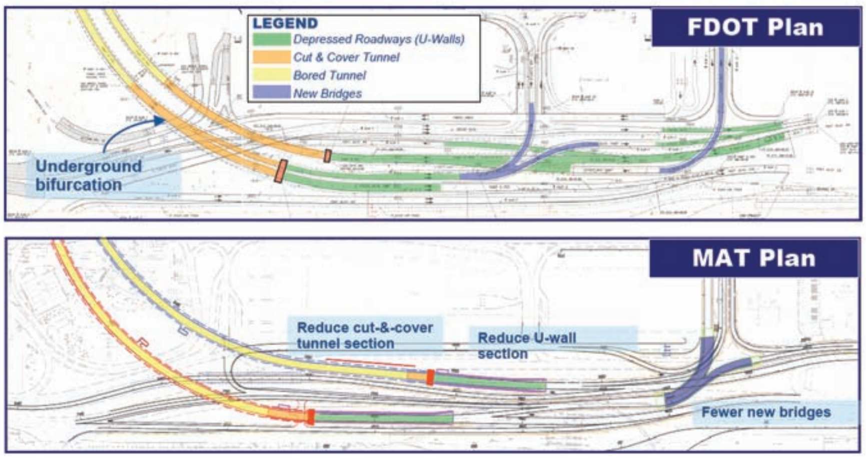


MAT design

Design philosophies of the MAT team are to minimize the risks, geological or political, that are anticipated to be encountered, maximize the efficiency of tunnel constructions, maximize the safety for surface and underground traffic operations and minimize the cost associated with the future operation and maintenance of the tunnel facilities. Many design enhancements to the FDOT indicate designs were investigated and evaluated. This paper only provides limited typical design enhancement examples, including:

FIG. 7

MAT vs FDOT plans — Dodge Island.



- Geological profile — a more detailed geological profile along the proposed tunnel alignment to reduce the potential geotechnical risks for TBM tunneling and machine selection.
- Tunnel design — extending the bored tunnel length and minimize the depth of cut-and-cover tunnel – cost effective TBM tunneling and minimize the risk of deep support of excavation.
- Traffic movement — Watson Island.

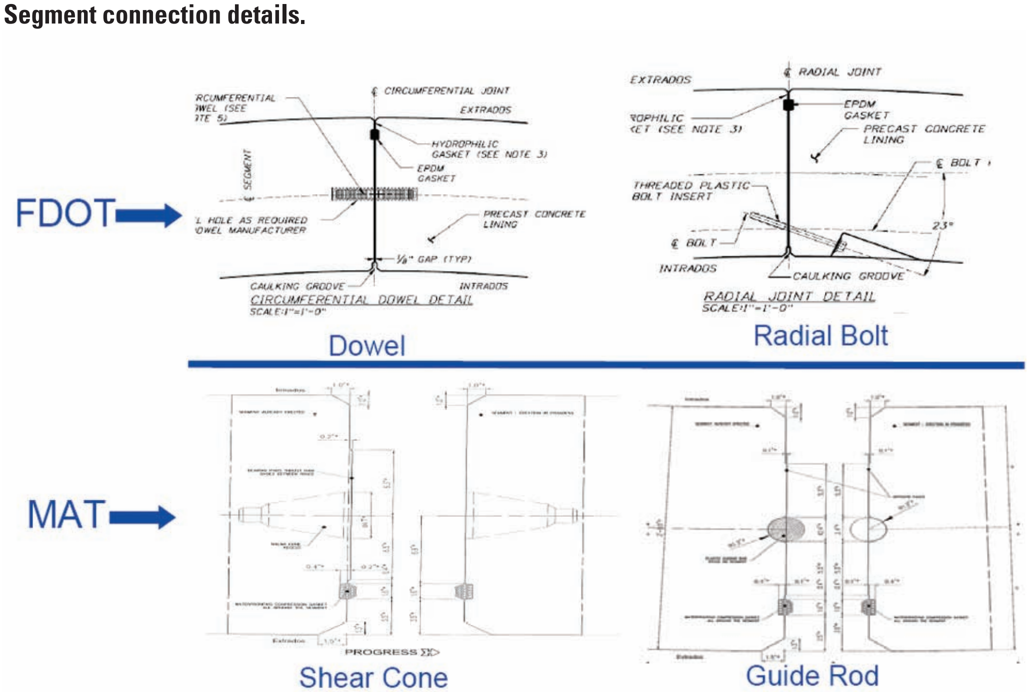
Geological profile

A detailed subsurface geological profile along the proposed tunnel alignment was developed. It consists of eight different layers, instead of four layers by the FDOT, including fill, compressible silty sand, Miami Limestone, sandy transition, Upper Fort Thompson, Fort Thompson Rock, loose to medium sand and Key Largo formation. Figure 6 shows the developed detail geological profile.

Table 2 makes a comparison of geotechnical profile interpretations made by the FDOT and the MAT. Interpretations of ground properties of each MAT layer were also made in Table 2.

FIG. 8

Segment connection details.



The detailed geologic profile interpretation facilitates the MAT team to select its tunnel construction means and methods, such as:

- The EPBM has to be operated in a closed face mode and be able to perform grouting from inside the TBM when tunneling under the ship channel.
- Ground improvements at the invert of the TBM are required on either end of the ship channel to prevent the "stepping-down" of the TBM during tunnel excavation, since loose-to-medium sand is expected at the bottom of the TBM. These ground improvements can be performed from the ground surface.
- Condition agent selection, either polymer or form, for each different ground zones to be encountered.

Tunnel design

The strategies are to maximize bored tunnel length and decrease the depth and length of both cut-and-cover tunnels and U-walls. The tunnel grade was flattened in Dodge Island and ground improvements were provided near tunnel portal areas such that the bored tunnel can be performed in much shallow depth compared with the FDOT indicative design. Figure 7 illustrates a comparison between MAT and FDOT indicative designs. The MAT design eliminated the FDOT designed bifurcation point, a traffic hazard, in the east bound cut-and-cover tunnel section. Also, because of the deeper alignment, the existing cruise line recreation center that is on the FDOT proposed alignment does not need to be relocated.

After detail tunnel electrical and mechanical designs, the MAT team concluded that the tunnel cross section designed by the FDOT is difficult to house all required tunnel system components. Therefore, the MAT design increased the inside tunnel diameter from 11 to 11.3 m (36 to 37 ft). Both its cross section and lining system are similar to that designed by the FDOT. Figure 3 shows the tunnel cross section comparisons, MAT tunnel lining consists of a 61-cm- (2-ft-) thick precast concrete segmental lining as required for security reason. However, its connection details for radial and circumferential joints are revised from that designed by the FDOT to facilitate segment erections. Shear cones were used in the circumferential joints and guide rods were used for radial joints. Figure 8 shows segment connection detail comparisons between FDOT's and MAT's.

Several support of excavation (SOE) systems were evaluated, including cutter soil mixing (CSM) wall, slurry wall and secant pile wall. The slurry wall was first excluded, since it has the potential of slurry leaking and loosing soil confinement when porous ground condition is encountered. CSM was seriously considered in the early design phase. However, it was also excluded because of strength capacity reasons for this site. Secant pile was selected as the SOE for cut-and-cover tunnels and for deep U-wall sections. For shallow U-wall sections, steel sheet piles were selected as the SOE systems.

Figures 9 and 10 show MAT cut-and-cover tunnel and U-wall sections, respectively.

Tremie seals are required for the cut-and-cover tunnel and U-wall sections to guard against the uplift hydrostatic pressure. Their construction sequences are:

- Installed secant pile wall.
- Excavate to the top of the ground water level and install cross lot bracing as needed.
- Excavating the remaining portion inside the secant pile wall in wet conditions until reaching the bottom of the tremie seal elevation.
- Install tension piles.
- Cast tremie seal and dewater the pit.
- Finalize the permanent structures within the pit.

Cross passage constructions will be under ground freezing conditions. The tunnel break-in scheme will use concrete block inside the launching pit to provide TBM confinement instead of ground improvement outside the pit. The tunnel break-out scheme will use the water pressure balance method, i.e., during tunnel break-out, the TBM receiving pit will be flooded prior to the TBM breakthrough.

FIG. 9

Typical MAT cut-and-cover tunnel.

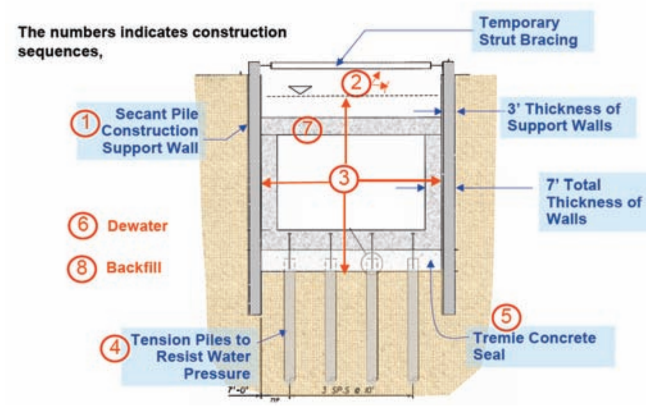
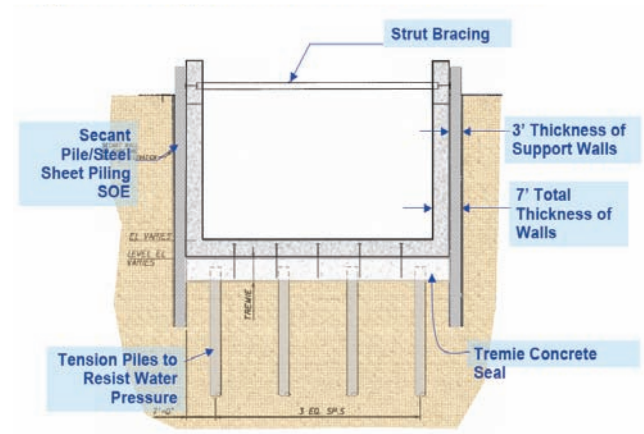


FIG. 10

Typical MAT U-wall section.



Traffic movement — Watson Island

The primary purpose of this project is to divert truck traffic to the POM from I-395 to Watson Island through the tunnel and then to the POM instead of through downtown Miami. This movement, by the FDOT design, has the potential for interference between the truck traffic to the POM, through I-395, with the passenger traffic, through Route 1, from downtown Miami to Miami Beach. The MAT design extended the bored tunnel length in Watson Island and at the same time eliminated the traffic interference weaving movement. Figures 11 and 12 illustrate these traffic movements.

Chronological project developments

Any underground project of this magnitude would take a long time from planning to design and to construction. And the Port of Miami Tunnel Project is no exception. This section provides the final and most critical development stage of this project in a chronological order, specifically from the years 2006 to 2008. It is summarized in Table 3.

Some major reasons for FDOT to terminate the project in December 2008 were:

- Agreement of the construction cost of the project could not be made on time. Though the MAT had started its pricing negotiation with the FDOT since February 2008, mutual agreement was not finalized. The cost proposal presented by MAT in 2006 required an adjustment to cover material and labor escalations, since the award was almost one year late. Interpretation of the GBR between the FDOT and the MAT was also a hurdle during the negotiation.
- The financial sponsor, Babcock & Brown, could no longer support this project after the financial downturn in the last quarter of 2008.

Since April 2009, FDOT has resumed negotiation with the MAT team and the MAT team has replaced its financial sponsor from Babcock and Brown to Meridiam. The fate of the project is now dependant upon the financial closer of the MAT team in October 2009.

Conclusions and lesson learned

The Port of Miami Tunnel project is well known for its engineering challenges, including design and construction in very difficult ground conditions and under a ship channel. Risks from geological conditions, hydrogeological conditions, construction means and methods, permits, utilities and funding commitments (from the state, the county and the city) were well addressed. Though most of the challenges and risks were eventually, or will be, overcome, the risk of the funding from the private financial sponsor was underestimated, which is a primary reason for this 20-year long planning project in the rim to be denied. Several lessons

Table 3

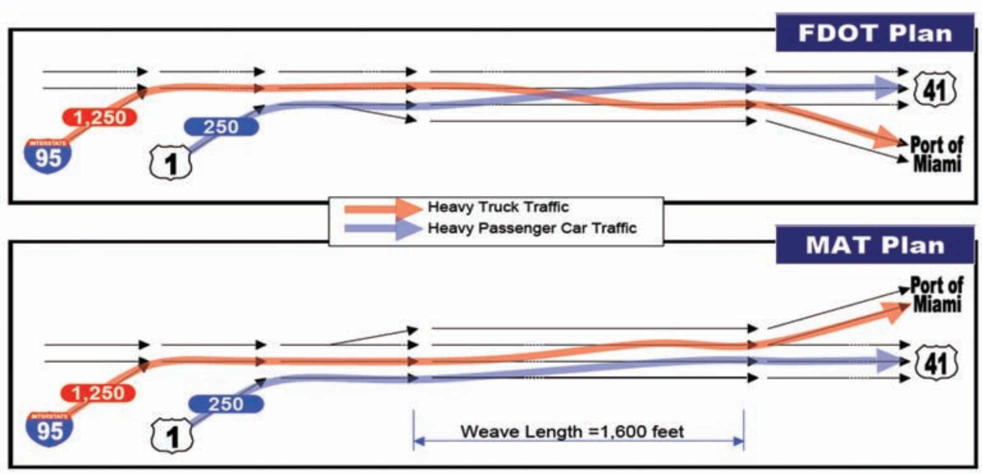
Chronological project developments.

Date	Significant events/activities
Feb. 17, 2006	FDOT publishes a request for qualifications (RFQ) for a DFBOM through a concession agreement.
April 12, 2006	FDOT receives statement of qualifications (SOQ) from potential proposers.
April 28, 2006	FDOT announces short-list of qualified proposers, Miami Mobility Group (Dragados / Odebrecht / Parsons), Miami Access Tunnel (Bouygues /ABN-AMRO), and FCC/ Morgan Stanley.
June 2006	FDOT published its schedule as follows: 1) prepare proposal: 7/06 - 11/06, 2) submit proposal: 11/1/06, 3) award concession: 1/4/07, 4) notice to proceed: 3/1/07, 4) permitting phase: 3/07 - 12/07, 5) construction phase: 9/07 - 4/12, 6) open to traffic: 2012, and 6) concession term: 2010 - 2045.
August 2006	Procurement schedule was identified: 1) early October, 2006 - FDOT publishes final request for proposals (RFP). 2) Mid-January, 2007 - FDOT receives proposals. 3) Late February, 2007 - FDOT makes final selection and awards contract. 4) Five year construction period beginning in 2007.
2 p.m. March 4, 2007	Actual date tender design submitted, which is three moths behind original schedule.
May 2, 2007	FDOT posted a notice of intent to award to MAT.
July 24, 2007	Miami-Dade County commissioners approved its funding contribution to the project.
Aug. 1, 2007	City of Miami commissioners voted to oppose using the City Redevelopment Fund on the tunnel unless the city wants to be repaid that money over the years from tolls that might be charged at the tunnel.
Feb. 15, 2008	FDOT awarded MAT consortium as the winning bidder for the Port of Miami Tunnel and the city of Miami agreed to its funding contribution of the project.
Dec. 12, 2008	FDOT pulling plug on the project.
April 16, 2009	FDOT re-negotiated the project with the MAT team.
June 1, 2009	FDOT and MAT reached commercial agreement.
Oct.1, 2009	Financial closure to be made by the MAT team.

are learned from the tender design of this PPP project, including:

FIG. 11

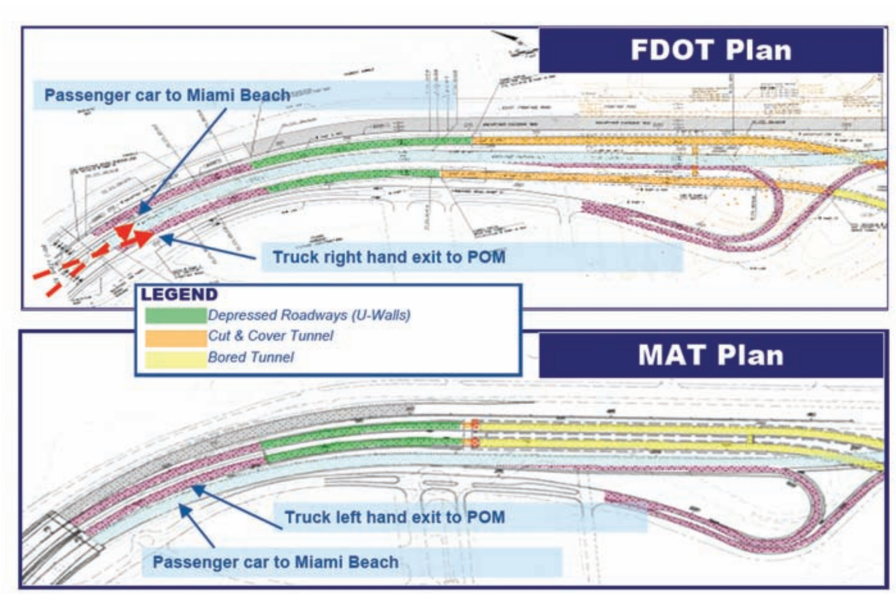
Schematic traffic movements — Watson Island.



- Financial risk of the concessionaire can be unpredictable and risky.
- High quality end products – It is different from a design-build project in that the concessionaire does not just design and build the agreed facilities. It also has to operate and maintain its constructed facilities for an agreed concession terms, which can be as long as more than 30 years. In this type of contractual mechanism, the contractor (and its design team) of the concessionaire has do its best to design and construct the facilities in a high and efficient standard, since the concessionaire is paid only when the facilities are open and functional.
- Innovation — Like the design-build project, the PPP encourages the cooperation between the contractor and the engineer through both design and construction phases. This can result in a creative engineering product that costs less for construction and achieves higher functional standards for end users
- Planning — Adequate time for planning is the only way to achieve best value solutions, especially for fast-paced projects.
- The purpose of the GBR — It is well known that this document has to be clear and concise and shall not be a document as much as a mechanism to shield the liabilities of the engineer of an owner. Like a design-build project, obtaining a consensus of this document can be difficult between the owner's representative/engineer and the concessionaire, since the baselines can be ambiguous and the concessionaire may select a scheme that alters the original alignment proposed by the owner. The purpose and the utilization of this document, especially for a design-bid-built contract, is well known for the U.S. underground design and construction communities. However, this may not be the case for foreign tunneling communities.
- Consensus baseline approach – We still need to resolve the issue of how we define the geotechnical baselines for design-build and PPP projects. Consensus approach does not exist. ■

FIG. 12

Traffic risk mitigation — Watson Island.



Reference

FDOT, 2006, Project Information Memorandum – Port of Miami Tunnel and Access Improvement Project.

Parsons Brinckerhoff, 2006. Geotechnical Baseline Report, Port of Miami Tunnel & Access Improvement. Prepared for the Florida

FEATURE ARTICLE

Onsite assembly and hard rock tunneling at the Jinping-II hydropower station tunnel project

The Jinping-II hydroelectric project in China features four parallel headrace tunnels approximately 18-km- (11-mile-) long. Two will be excavated by tunnel boring machines (TBM) and two by drill-and-blast. A nearby fifth tunnel is being excavated by a 7.2-m (23.6-ft) TBM to draw down ground water in advance of excavating the headrace tunnels.

Unique onsite assembly of a 12.43-m (40.7-ft) main beam TBM and backup system was completed on Sept. 18, 2008 in the remote mountains of the Sichuan province. The equipment was assembled onsite, without previously having been assembled and tested in a factory, using a method called onsite first time assembly (OFTA).

This paper addresses the following topics:

- Project description including geology and terrain.
- The decision process leading to onsite, first time assembly, the assembly process and logistics, and lessons learned.
- Design features of the TBM and backup system.
- Operational history from startup to the writing of this article.

Project description

Jinping-II will be the largest power station (Fig. 1) in an ambitious 21-station mega project for owner Ertan Hydropower Development Co. Ltd. (EHDC). The total 21-station project will harness power from the Yalong River for China's West to East electricity transmission project. EHDC began the scheme in 1991, constructing the Ertan hydroelectric project in the west of Sichuan province. The project was officially completed in 2000 with an installed capacity of 3,300 MW. Additional projects in the lower reaches of the Yalong are planned for completion before 2015, including Jinping-I (3,600 MW), Jinping-II (4,800 MW), Guandi (2,400 MW) and Tongzilin (600 MW). All remaining projects are to be finished by 2025. Currently, three power stations are being built or are already online (Ertan, Jinping-I and Jinping-II), while the others are in various preparatory stages.

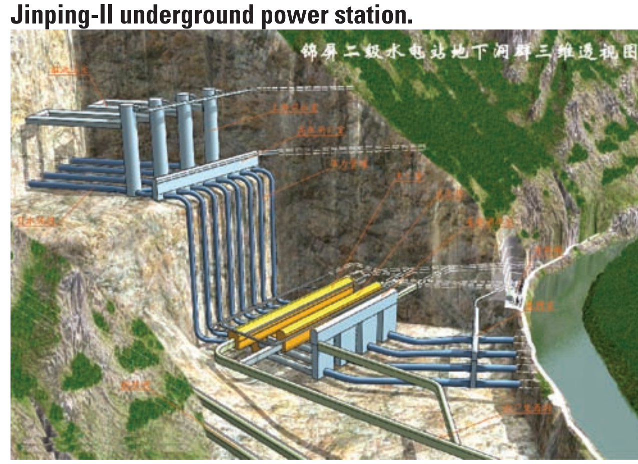
Stephen M. Smading, Joe Roby and Desiree Willis

Stephen M. Smading, Joe Roby, member UCA of SME and **Desiree Willis,** are project manager, vice president and technical writer, respectively, with the Robbins Co., e-mail sales@robbinstbm.com.

Power from these stations and other resources in the west will be transmitted to Guangdong, Jiangsu and Zhejiang provinces, as well as the cities of Shanghai, Beijing, Tianjin and other eastern locations, where electricity is now in short supply.

FIG. 1

Jinping-II underground power station.



The entire scheme is envisaged to go online in 2030 and will have a generation capacity of close to 30 GW.

Preliminary geological surveys, feasibility studies and necessary approvals for the large-scale development of Jinping-II and other stations have been ongoing for the past 40 years. In 2003, work began on the 62-km- (38-mile-) long main road leading to the Jinping-II jobsite.

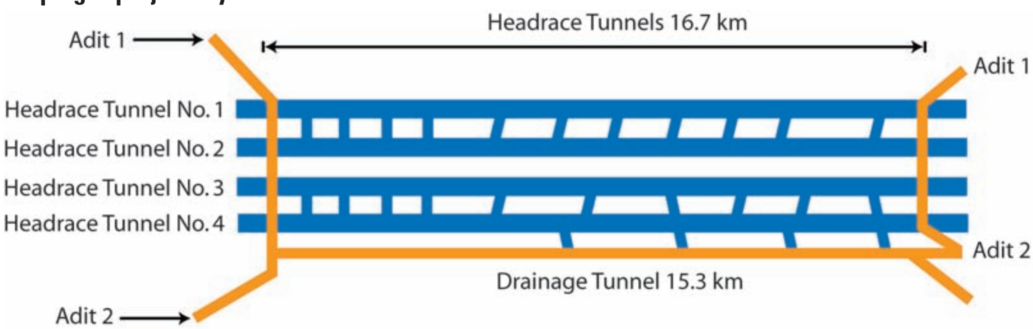
The Jinping-II site is unique in that it will use a 180° natural hairpin bend in the Yalong River, a tributary of the Yangtze, to generate a multi-year average annual generation of 24.23 TWh. From the intake structure, the river flows north before turning abruptly south as it flows around Jin Ping Mountain. The distance along the river from intake to outlet is approximately 150 km (93 miles), during which the river drops 310 m (1,020 ft).

From intake structures near Jingfeng Bridge, water will flow through the four Jinping headrace tunnels downgrade at 3.65 percent to the underground Dashuigou powerhouse. The powerhouse will use eight 600-MW turbine generators for a total generating capacity of 4,800 MW. The four parallel headrace tunnels, with an average length of 16.6 km (10.3 miles), are separated by 60 m (197 ft) from centerline to centerline. Two access tunnels and a drainage tunnel run parallel to the headrace tunnels on the southern side.

Ertan Hydropower, the owner, split the tunneling contracts in two. One contract was let for headrace tunnels Nos. 1 and 2, and a separate contract was let for tunnel Nos. 3 and 4. The tender documents specified that two 12.4-m- (40.1-ft-) diameter TBMs would excavate 16.7-km- (10.4-mile-) long sections of headrace tunnels Nos. 1 and 3. As a result, each of the construction contracts includes one TBM-bored tunnel and one drill-and-blast excavated tunnel. China Railway 18th Bureau (Group) Co. Ltd. won the construction contract for headrace tunnels Nos. 1 and 2, while China Railway 13th Bureau (Group) Co. Ltd. won the contract to construct headrace tunnels Nos. 3 and 4.

FIG. 2

Jinping-II project layout.



Parallel to the headrace tunnels is the 15.3-km- (9.5-mile-) long dewatering tunnel that is being excavated under separate contract by Beijing Vibroflotation Engineering Co. (BVEC) with a 7.2-m- (23.6-ft-) diameter TBM. This tunnel is being excavated ahead of the four headrace tunnels in order to reduce the water inflow in the headrace tunnels well below the 5 m^3/s (176 cu ft/sec) otherwise expected (Fig. 2).

Geology and tunnel alignment

All four tunnels are located on the slopes of Jinping Mountain in reportedly stable geology consisting of massive to blocky marble with limestone, sandstone, slate and chlorite schist with unconfined compressive strength (UCS) of between 50 and 85 MPa.

FIG. 3

High cover at Jinping-II job site.

A high overburden, with more than 70 percent of the cover greater than 1,500 m (4,900 st) and a maximum of 2,525 m (8,300 ft), creates a risk of squeezing ground and rock bursts (Fig. 3). Pre-excavation core tests typified rock in the tunnel as:

- Class II (RMR 61 to 80): 29.1 percent of tunnel.
- Class III (RMR 41 to 60): 53.6 percent of tunnel.
- Classes IV and V (RMR < 41): 17.3 percent of tunnel.

Though the rock should provide relatively good conditions for excavation, there are several challenges to overcome. One is the potential for sudden inundation of the tunnel during the excavation work. Underground water in the vicinity is reportedly conveyed by fissures and a network of channels with a continuous water source, resulting in the possibility of high pressure and large flow rates. Core tests revealed a potential for steady flows in the range of 2 to 3 m^3/s (71 to 106 cu ft/sec) (with maximum water flows of up to 5 m^3/s (177 cu ft/sec) (Wu & Huang, 2008).

Another challenge is rock bursts, which may occur as a result of the high in situ stress caused by high cover. Again, according to Wu & Huang, measured maximum major principal stress is approximately 42 MPa vertical, indicating that gravity stress dominates. They reported that the major and minor principal stresses could reach 63 MPa and 26 MPa, respectively, in the headrace tunnel at the point of maximum overburden.

Severe rock bursts occurred during excavation of the access tunnels and an adit. Therefore, some rock bursting is expected during construction of the headrace tunnels.

In response to the core test results and high cover, an aggressive ground support program has been developed with various support designs specified based on the rock mass classification. In relatively stable rock, support is minimal including sparse rock bolts. In rock mass Class III, systematic rock bolts up to 6-m- (20-ft-) long are installed, as well as steel-fiber reinforced shotcrete. Class IV and V sections are also stabilized with rock bolts and reinforced shotcrete, and final lining will include concrete

FIG. 4

Partial shop assembly.

up to 70-cm- (27-in.) thick.

Measures to handle ground water

During excavation of the headrace tunnels, the contractor will attempt to reduce and control the volume of water inflows using several approaches:

Pre-excavation draining. This plan specifies dewatering the mountain by draining water into the 7.2-m (23.6-ft) dewatering tunnel, which is being excavated by TBM in advance of excavating the headrace tunnels.

Pre-excavation probing. Rock drills are employed to drill ahead of the TBM, probing for changing geological and hydrological conditions. Information so gleaned will be used to specify pre-excavation rock consolidation and water cutoff grouting programs, as well as to anticipate near-future rock support measures for safe tunneling. It is imperative that any incoming water flow be limited to allow continued excavation by the TBM.

Post-excavation draining. The construction design, including the TBM design, allows for large volumes of water to be drained through the bored headrace tunnels as they are excavated, minimizing impact on excavation logistics and TBM operations.

Controlling. The concept for this step is to give the constructor the ability to control the rate at which the ground water is drained into the tunnel, from every point in the excavated tunnel. In this way, it is hoped that water can be allowed to flow into the bored tunnel to the maximum allowable volume rate that will allow continued TBM operations. Ideally, if successful, the system would permit the constructor to drain where and when necessary to maintain operations. This will require, of course, high-quality water cutoff grouting, drain pipes and valves.

Rock bursts

The high in situ stress along the headrace tunnel can cause rock bursts during excavation. Measured stresses may reach 63 MPa at the site of maximum overburden. Several measures have been specified by the project owner to reduce the potential for rock bursts during headrace tunnel excavation, including:

TBM usage. Headrace tunnels Nos. 1 and 3 will be excavated by TBM to a total length of about 16.7 km (10.4 miles). The rock mass surrounding a TBM-bored tunnel is disturbed less than it is with drill-and-blast excavation. It is hoped that the use of TBMs on two of the four headrace tunnels may reduce the rock stresses enough to somewhat reduce the probability of rock bursts in all four tunnels.

Reinforcement of the surrounding rock masses. Maintaining as much of the rock in place as possible after excavation (i.e. minimizing over break or rock fall) results in better total rock support through the formation of a natural arch and reduces post excavation stress. Rock support has been designed to keep as much rock in place as possible, these include:

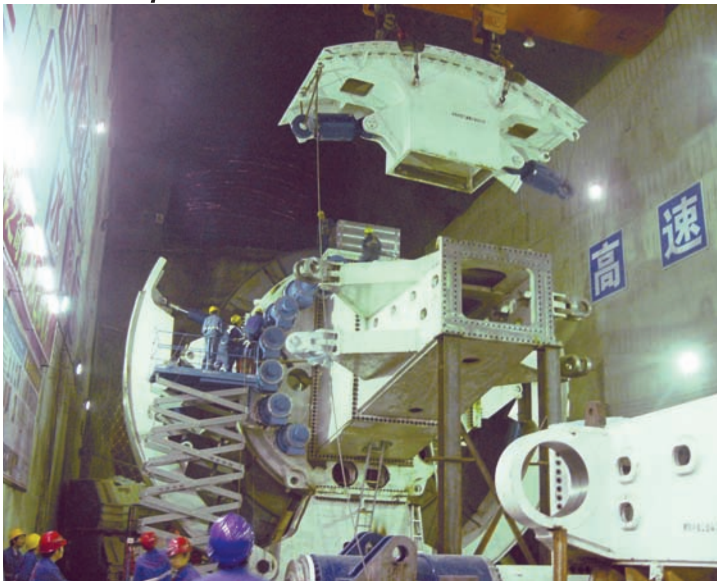
- Shotcrete or steel-fiber-reinforced shotcrete applied immediately after the excavation.
- Patterned rockbolts to prevent the loss of rock blocks and slabs.
- Wire mesh or steel ribs.

Onsite first time assembly

Onsite first time assembly (OFTA) was selected for the 12.4-m (41-ft) TBM due to fast track project scheduling and a limited seasonal window for delivery to the site by river. The OFTA process, developed by the Robbins Co., allows machines to be assembled at the job site without need of pre-assembly in a manufacturing facility. The

FIG. 5

TBM assembly in the chamber.



process was first used in 2006 on the 14.4-m- (47-ft-) diameter TBM at the Niagara Tunnel project — the world's largest hard rock TBM. OFTA has since been used on several projects around the world, resulting in reduced TBM startup schedules and cost savings due to decreased shipping costs and man hours.

OFTA was identified as essential for the Jinping project because it would enable early shipment of large components of the TBM. Rapid shipment of the large components was needed in order for them to be moved by barge on the Yangzi River (also known as the Yangtze River) before the onset of the low water season between November and April. The area sees vastly different seasonal rainfall, with the May to October rainy season accounting for as much as 95 percent of annual rainfall.

All of the heavy structural parts of the TBM were manufactured in a facility located in the city of Dalian in northeast China. Under the original site assembly plan, preassembly of some TBM components was to have begun on site in late November 2007.

That assembly schedule required that all of the parts arrive at the Le Shan dock near the city of Chengdu on the Yangtze River in early November 2007 before the low water season started. However, by the end of the summer of 2007, the original assembly schedule was delayed because the site was not ready to receive the equipment.

Additionally, the Yangtze River experienced unusually heavy flows that year. For these reasons, the decision was taken to partially assemble some of the critical parts in the Dalian factory before shipping. The main bearing, gear and pinions were installed in the cutterhead support so the ring gear-pinion mesh could be verified. Later, the muck chute, side supports, roof support and front support were attached. The remaining components were assembled for the first time on site (Fig. 4).

FIG. 7

Portable boring machine.

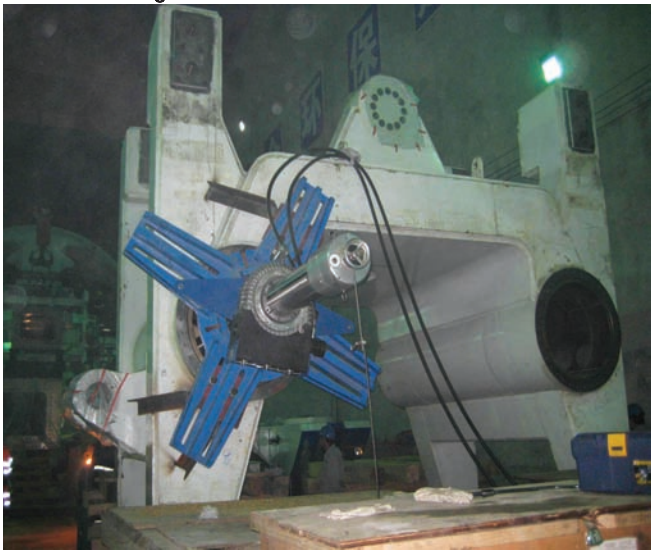


FIG. 6

Hydraulic workshop.

At the end of 2007, all of the heavy structures were loaded on a barge, shipped up the river and placed in a storage yard near Chengdu until the job site was ready to receive them.

Though all of the structural components of the TBM and backup were manufactured in China, subsystems, such as hydraulic, lubrication, water, electrical and ventilation, were manufactured and tested in facilities in the U.S. or Europe before being shipped to the site.

Key components of a successful OFTA program include:

- Quality control of component manufacture to ensure proper fit at the site.
- Absolute control of the total system bill-of-materials, to ensure that everything required for the system is sent to the job site.
- Logistical planning and control, to ensure that everything arrives at the job site in the order that it is required for efficient assembly and use of storage space.
- Resources planning, to ensure that all tools and personnel of every type and quantity required for assembly are on site when required.
- Advance alternative recovery planning, to be ready to react quickly to possible failures in any of the above steps.

Much of the challenge of the assembly was a result of the remote location. Once at the site, the 12.4-m- (41-m-) machine was erected in an underground assembly chamber measuring 20-m-wide x 26-m-high (66-ft x 85-ft). Limited space required that many of the smaller TBM components, the parts imported from outside China, and all of the backup structures be staged about 80-km (50-miles) away in the town of Manshuiwan where warehouse space and a large outdoor yard were provided by Ertan.

FIG. 8

Fully assembled 12.43-m-(40.1-ft-) diameter TBM.

Every morning a coordination meeting was convened to plan which parts should be sent to the site for the next day's scheduled work. The designated parts were loaded on trucks that day and sent to the assembly chamber, arriving later that evening to be available for the next morning's assembly (Fig. 5).

Because of the remote location and because the TBM had not been previously assembled, it was necessary to equip several shipping containers as workshops. A hydraulic workshop was set up with the hose ends and adapter fittings needed, as well as a high-production hose crimping machine (Fig. 6). Similarly, an electrical container, a tool container, a workshop container and an office container were mobilized in the assembly chamber.

Assembly of the TBM and backup system began in July 2008 and finished on Sept. 17, a schedule comparable to that for site assembly of a large diameter TBM that has been pre-assembled in the factory. Crews then walked the TBM and the first three backup gantries 200 m (656 ft) forward from the assembly chamber to a launch chamber. The vacated assembly chamber was then used to erect the conveyor system and six more backup gantries.

In general, the assembly sequence proceeded according to the plan, with one major exception. Early in the assembly program, it was discovered that the gripper carrier bushings had not been finish-machined in the manufacturing facility in Dalian.

Shipping the carrier to the nearest machine shop in Chengdu for repair would have been the preferred way to solve the problem. However, this was impossible because of damage to machine tools and factories resulting from the severe earthquake that hit Sichuan province in May 2008. Instead, a contractor in Shanghai was brought to the site with a portable boring machine and the gripper carrier bushings were line-bored in three days. (Fig. 7).

Another major difficulty was the lack of skilled local workers. For this reason, intense supervision and training of these workers was necessary to ensure the quality of the final product. Robbins had as many as 16 supervisory personnel from the U.S. and Europe and 26 engineers, mechanics and electricians from Robbins (China) Underground Equipment Co., Ltd. at the peak of the assembly effort.

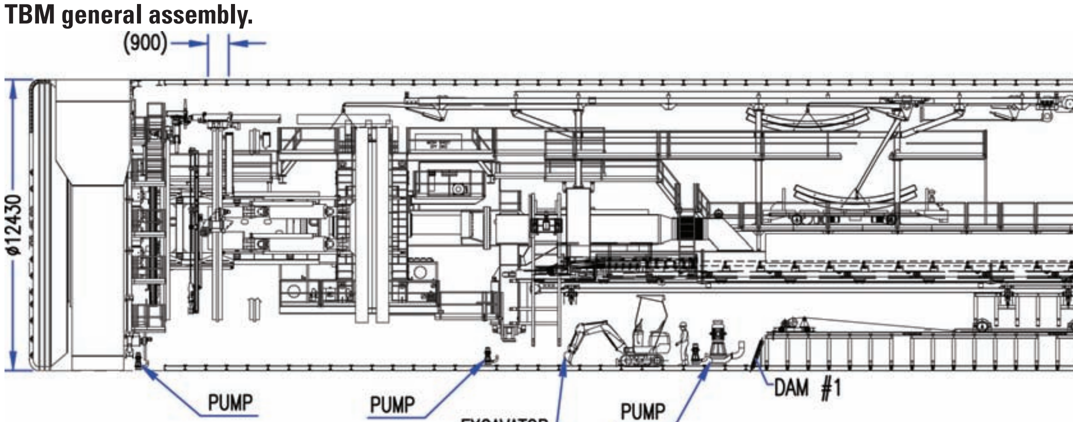
The equipment was successfully assembled and launched in only three months, despite record snowstorms that caused major delays, as well as 2008's magnitude 8 earthquake centered near Chengdu, which caused heavy road damage and further delays to the schedule (Fig. 8).

TBM features and design criteria

Robbins specially designed the 12.43-m (41-ft) TBM for high water inflows and difficult ground conditions (Fig. 9). Several measures are being taken to address the

FIG. 9

TBM general assembly.



possibility of deep, flowing water in the invert under the TBM. With the exception of the cutterhead and cutterhead support, the lowest parts of the TBM, backup and continuous conveyor systems are 1.5 m (5 ft) above the tunnel invert. In addition, the tunnel train track is assembled on a continuously installed steel framework, also 1.5 m (5 ft) above the tunnel invert. Keeping all of the equipment 1.5 m (5 ft) above the tunnel invert allows a water inflow of approximately 4,000 L/sec (15,141 gal/sec) to pass under the boring equipment and trains with minimum impact on tunnel excavation.

Primary rock support activities are performed from platforms on top of the TBM. Ring beams are delivered in the top of the tunnel, through the backup and over the top of the TBM main beam to the ring beam erector. A panel erector can install specially designed steel panels over fissures in the rock where water is entering at high pressure, to deflect and redirect the water spray.

Moveable steel dams can be placed in the invert just behind the TBM and dewatering pumps are available to relay water from the cutterhead support area to the end of the backup. The configuration keeps the water level as low as possible under the TBM in the primary tunnel working area.

The working decks on top of the backup are covered by steel canopies to protect personnel from high-pressure or high-flow water (Fig. 10).

Rock bolting is done in two locations on the TBM. The L1 zone, located just behind the cutterhead support, has two drills. The L2 zone, on the backup is just behind the bridge conveyor. It has two more drills.

Shotcrete can be applied in the L1 and L2 areas. In L1, a single robot is used for emergency application of shotcrete. Production shotcreting is done in the L2 area with two robots, one on each side of the backup. The L2 robots have an axial stroke of 12 m (40 ft) and a pumping capacity of 25 m^3/h (882 cu ft) each. The backup gantries where the L2 drills and shotcrete robots are located are configured as 6-m- (20-ft-) diameter steel tubes. All shotcreting and drilling takes place on the outside of the tubes to protect the facilities on the inside of the tubes and to allow free passage of workers and materials during ground support activities (Figs. 11, 12 and 13).

Following the L2 zone rock support equipment decks are several three-level backup decks on which various equipment is mounted and various workstations are located (Fig. 14).

Table 1

TBM general specifications.

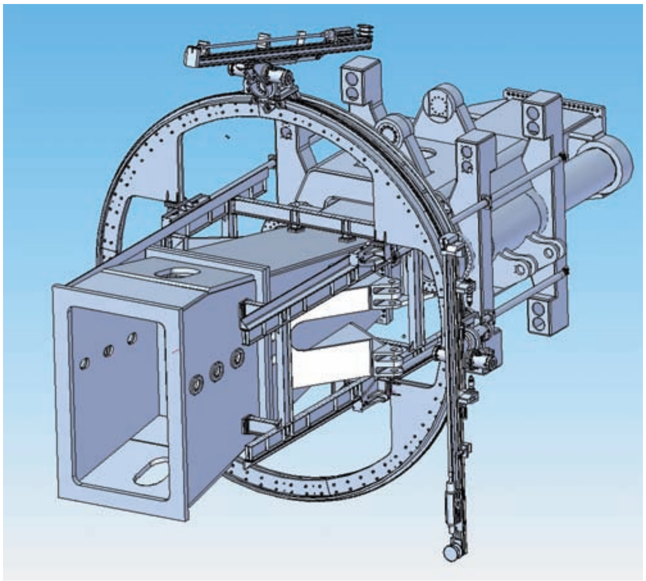
Year of manufacture	2008
Machine diameter (new cutters)	12.42 m (40.7 ft)
Cutters	
Face/gage	Series 19 (482.6 mm)
Center	Series 17 (431.8mm)
Number of disc cutters (overcut not included)	78
Number of disc cutters overcut	2
Maximum recommended individual cutter load	267 kN (60,000 lbs.)
Cutterhead	
Recommended normal operating thrust	20,826 kN (4,681,871 lbs.)
Cutterhead drive	Electric motors/safe sets, gear reducers
Cutterhead power	4,410 kW (14 x 422.4 hp) (5,914 hp)
Cutterhead speed	0-5.61 rpm
Approximate torque (low speed) 0-2.55rpm	16,519 kNm
Approximate torque (high speed) 5.61 rpm	7,509 kNm
Thrust cylinder boring stroke	1,884 mm (74.2 in.)
Hydraulic system	225 kW (300 HP)
System operating pressure at maximum recommended cutterhead thrust	300 bar (4,351 psi)
Maximum system pressure	345 bar (5,000 psi)
Electrical system	
Motor circuit	690 VAC 3-phase, 50 Hz
Lighting system/control system	230VAC/24 VDC
Transformer size	2 x 3000 kVA, 1 x 2000 kVA
Primary voltage 20,000 V 50 Hz	690 VAC drive motors,
Secondary Voltage	400 VAC hydraulic pump motors
Machine conveyor	
Width	1,370 mm (54 in.)
TBM weight (approximately)	1,256 t, excluding drilling equipment

FIG. 10

Backup system with steel canopies.

FIG. 11

Project location plan and alignment.



The TBM is a Robbins high-performance TBM that combines very heavy structural steel components, a very high capacity 3-axis/3-roller main bearing, high-thrust and high-power. The cutterhead has 4,410 kW (3,288 hp) of power and is fitted with 482-mm (19-in.) back-loading cutters with two extra housings installed in the gage area for overboring in the event squeezing ground is encountered (Table 1).

Mucking systems

In anticipation of high water inflows, the conveyors on the TBM and backup are designed to be completely horizontal to minimize the high spillage rates associated with inclined conveyors carrying muck and large amounts of water. The bridge conveyor, located just behind the TBM conveyor, is straight for two-thirds of its length and then curves to the side, discharging directly into the advancing tailpiece on the right hand side of the tunnel. Curving the conveyor was necessary to eliminate the usual transfer conveyor between the bridge conveyor and tunnel conveyor. With the elimination of the transfer conveyor, it was possible to keep the bridge conveyor completely flat.

Muck is transported from the TBM by a continuous

FIG. 12

Additional rock drills are on the backup for secondary bolting outside of the 6-m (19-ft) tube.

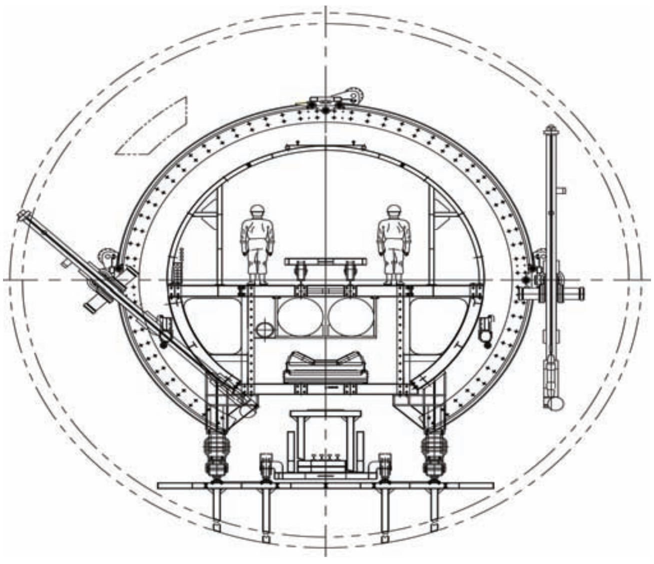
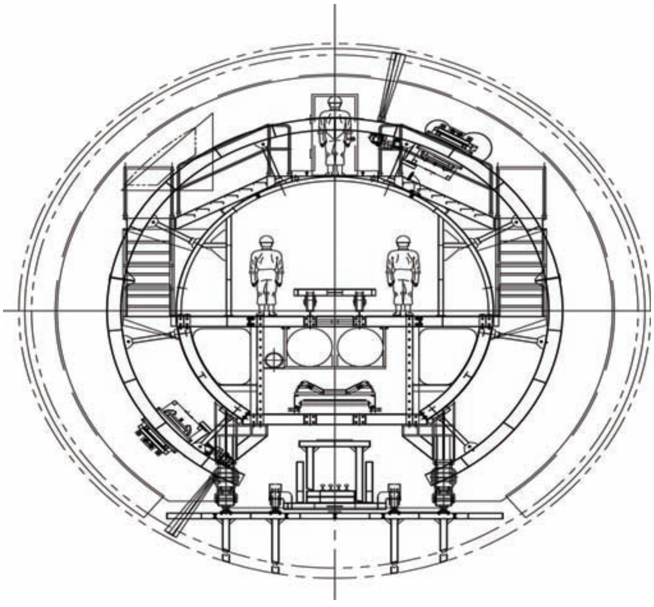


FIG. 13

Shotcrete robots work outside of the totally enclosed central working area.



conveyor system that will eventually be 16.7 km (10.4 miles) in length (Fig. 15). The steel cable core conveyor belt system uses a 1,200-kW (895-hp) main drive with a 1,200-kW (895-hp) booster drive that will be installed at the midpoint of the tunnel.

The TBM tunnel No. 1 conveyor capacity is large, at 1.8 kt/h (1,984 stph), to be able to handle crushed rock from the adjacent drill-and-blast tunnel No. 2 in addition to the TBM-generated muck from tunnel No.1. The tunnel conveyor discharges to a series of conveyors intended to handle muck from all four headrace tunnels and the dewatering tunnel. Final disposal is in a deep valley 7 km (4.3 miles) from the portal. The dewatering tunnel uses a similar steel cable belt system 15.4 km (9.6 miles) in length.

Operational history

The assembly of both 12.4 m (40.7 ft) machines was completed in the autumn of 2008, while the 7.2-m (23.6-ft) machine was launched in May 2008. As of late October, the Robbins machine at headrace tunnel No. 1 was undergoing testing and had advanced more than 300 m (984 ft) of its 2,000-m- (6,561-ft-) long commissioning bore. Increased ground support was required at the interface between the starting chamber and the bored tunnel and took some time to be agreed. The resulting design included ring beam installation every 900 mm (35 in.) and a 17-bolt pattern of rock bolts every 1.5 m (5 ft). Progress has been slow to date due to very poor rock conditions. The face is fractured and collapses. Similar rock conditions were present during the first 1.5 km (1 mile) of the dewatering tunnel then improved.

It was hoped that conditions would also improve in the head race tunnels.

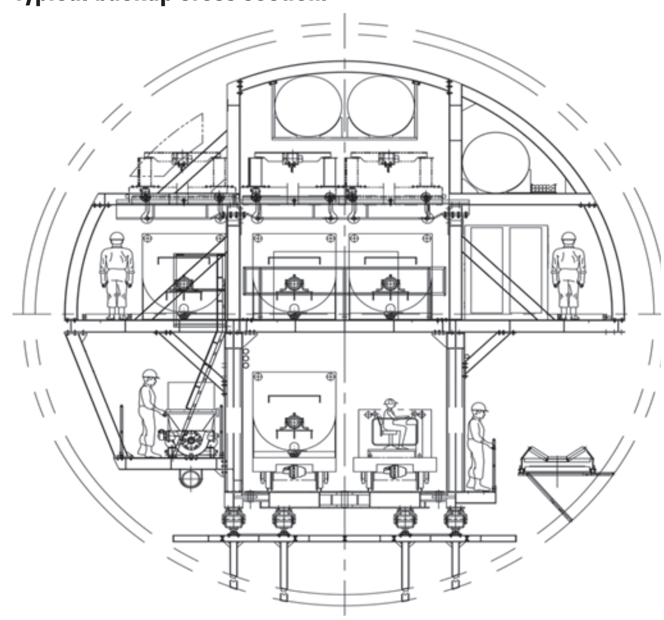
Excavation at the dewatering tunnel had advanced 2,890 m (9,500 ft) as of January 2009 at rates of up to 50 m/d (164 ft/d). Boring is done in two 10-hour shifts with a four-hour maintenance shift. Operations at the drill-and-blast tunnels were also under way and had advanced approximately 2 km (1.2 mile) in headrace tunnel Nos. 2 and 4.

FIG. 15

Shotcrete robots work outside of the totally enclosed central working area.

FIG. 14

Typical backup cross section.



The TBM for the dewatering tunnel is expected to finish in late 2009/early 2010, while the machine at headrace tunnel No. 1 is slated for a mid-2012 breakthrough.

Conclusions

Excavation of the Jinping-II headrace tunnels presents many formidable challenges. A condensed construction schedule required a new approach to TBM design and manufacture that resulted in the use of OFTA for rapid launch of the machine, shaving months off the schedule. The extremely high water inflow potential required new methods. Some of the new methods planned to battle the water are untested.

Tunneling under more than 2 km (1.2 miles) of cover and the attendant rock stresses and potential for spalling and rock bursts would be very challenging, even in the absence of water.

At Jinping, the extremely remote site location, high water pressure and inflow potential, and 2 km (1.2 miles) of cover combine to make it one of the most challenging tunneling projects of the day. Regardless of the tunneling production rates finally achieved on the project, one outcome is inevitable; lessons will be learned on this project that will make possible future projects in mountainous regions of China, and even larger ranges such as the Himalayas and the Andes. ■

References

Wu S. and Huang Z., 2008, Tunnel Vision at Jinping II. Int. Water Power & Dam Construction. www.waterpowermagazine.com/story.asp?storyCode=2050980. Retrieved January 12, 2009.

Ertan Hydropower Plant, Yalong River, China. Power Technology.com http://www. power-technology.com/projects/ertan/ Retrived January 17, 2009.

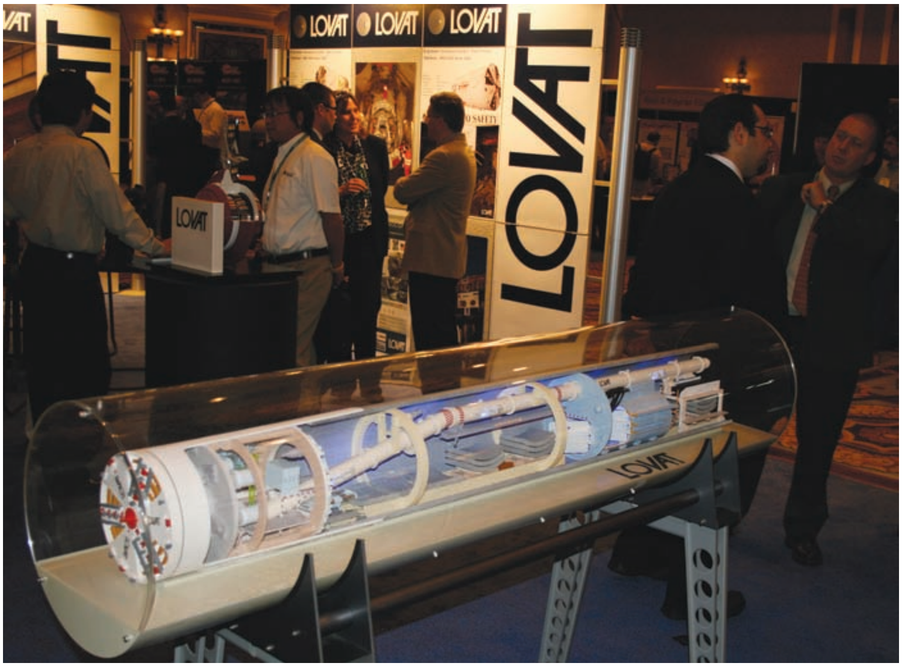
FEATURE ARTICLE

More than 1,300 attend RETC in Las Vegas

The global recession of the past two years has sent many industries into a tailspin, with the natural retrenchments by industry and the accompanying job losses.

The underground space and tunneling industry has taken its hits, too, but not as bad as others, such as mining or housing. That was reflected in the attendance at the Rapid Excavation and Tunneling Conference (RETC), held June 14-17 at Caesars Palace in Las Vegas, NV. Attendance reached 1,373 underground space professionals from around the world, up from 1,334 in 2007 when the conference was held in Toronto, Ontario. And the accompanying exhibit included 150 booth spaces sold, up from 125 in 2007.

Attendees were able to see the latest in technology at the RETC in Las Vegas.



The conference included more than 100 papers in 20 technical sessions. Proceedings from the 2009 RETC are available from SME for $111 for members and $179 for nonmembers. Contact: Customer Service, 8307 Shaffer Parkway, Littleton, CO 80127, phone 800-763-3132, 303-948-4200, e-mail sme@smenet.org, Web site www.smenet.org.

Technical presentations

Tunneling in the Andes. The use of tunnel boring machines (TBM) for the construction of long tunnels in the Andes Mountains of South America has been met with mixed success throughout the years. Dean Brox, of Hatch McDonald, and Guido Venturini, of Sea Consulting, examined several past projects that involved the use of TBMs. They outlined some of the lessons learned from successful projects as well as projects that were abandoned.

Some of the key considerations for tunneling in the Andes include geological, including faults, rock type, rock strength, rock abrasiveness, durability and ground water inflows, the authors said. Other considerations include depth of cover and the potential for overstressing/rockbursts, site access and terrain, portal locations, intermediate accesses possibilities, minimum tunnel size, support requirements, contractor and labor experience, and project handling costs. The authors examined each of those factors.

Steve Kral, Editor

The major lessons learned from past tunnel projects is that every tunneling project's site location is unique in its geology, access, terrain/cover, experience of candidate contractors and project schedule demands. TBMs are not always the best solution for all major and long tunnel projects, the authors said. However, TBMs have contributed significantly to the completion of several major tunnel projects in the Andes despite encountering challenging ground conditions.

Blind shaft drilling advances. Blind shaft drilling is a niche market that falls between conventional shaft sinking and raise boring. As such, blind shaft drilling has not seen much in the way of technology improvements since the 1970s, according to Alan Zeni, of Frontier Kemper Constructors.

During the 1990s, though, blind shaft drilling saw some increased demand in foundation and deep piling work. Wirth GmbH from Erkelenz, Germany has been active the blind shaft drilling market for many years, making pile top drilling rigs and tools. Recently, Frontier Kemper and Wirth entered into an agreement to develop a new generation of large diameter blind drilling equipment that was specifically aimed at mining needs, Zeni said.

The result is the DHI-240. Zeni described the technology involved with the new rig and presented a case study. The DHI-240 was designed for drilling large diameter shafts using the blind drilling method, Zeni said. The process is a hybrid of rotary drilling, such as used in the oil, gas and well drilling, The blind drilling method uses a similar mechanism and technique as rotary drilling, except the tools are larger and move slower, he said.

Some of the attributes of the DHI-240 are:

- The draw works are driven with a 224-kW (300-hp) variable-speed ac electric motor. This allows the draw works to failsafe and are easily controlled with dynamic braking, automatic parking and emergency brakes.
- The 346-t (382-st) capacity mast can tilt hydraulically to make rigging, tool handling and casing installation easier and safer.
- The rig has the necessary clearance for handling 6-m- (20-ft-) diameter drilling assemblies.

UCA of SME activities

During the welcoming lunch, the UCA of SME presented its awards to outstanding members and the Project of the Year. George D. Yoggy received the division's Lifetime Achievement. Galyn "Rip" Rippentrop received the Outstanding Individual Award. And the Project of Year Award was the Narragansett Bay Commission's Combined Sewer Overflow Abatement Project in Providence, RI. More details on the winners were published in June 2009 issue of *T&UC*, on page 38.

Also during RETC, David R. Klug, of David R. Klug & Associates, was installed as the 2010 chair of the UCA of SME, succeeding Brenda Bohlke. Jeffrey P. Petersen, of Kiewit Construction Co., is vice chair. And two new Executive Committee members were installed, Robert J.F. Goodfellow, of Black & Veatch Corp., and Lester M. Bradshaw Jr., of Bradshaw Construction Corp. Personal details of those four are on page 37.

Exhibit

The exhibit at the 2009 RETC was one of the largest in recent years, with 150 booths. Equipment suppliers and consulting companies were on hand to demonstrate the latest in underground construction technologies. Here is a sampling of some of the exhibiting companies.

Alpine Equipment. Headquartered in State College, PA, Alpine Equipment is North America's oldest supplier of roadheaders, shaft sinkers and cutter head attachments for all sizes of excavators and tunnel shields. The company also supplies tunnel boring equipment, hydraulic hammers and drills, and other underground construction equipment. Alpine Equipment recently introduced its novel cutter-bucket combination that can cut and muck concurrently.

The attendance at RETC reached 1,373 and 150 exhibit booths were sold.

Alpine Equipment's engineers and scientists can assist contractors and consultants in equipment selection and production/cost estimation. The company said a rule of thumb is that roadheaders and cutter head attachments can excavate tunnels twice as fast and at a third of the cost of drilling and blasting. And they are three to four times faster than hammers in trenching work.

Atlas Copco CMT-USA. Atlas Copco is a global provider of industrial productivity solutions. Products and services range from compressed air and gas equipment, generators, construction and mining equipment, industrial tools and assembly systems to related aftermarket services.

The company, with U.S. headquarters in Commerce City, CO, provides grouting services equipment and material, hydraulic hammers, drills and rockbreakers, pumps and pumping equipment, and shaft drilling and raiseboring equipment.

Boart Longyear E&I Drilling Services. Headquartered in Marietta, OH, Boart Longyear is a leading integrated drilling services provider. The company does business in the minerals, environmental, infrastructure and alternative energy industries.

For the tunneling industry, Boart Longyear provides sonic drilling technology to characterize soft rock tunneling applications. The company used the penetrating and sampling capabilities of sonic drilling to provide the best information, enabling the best decisions. Boart Longyear also offers a variety of conventional drilling services, including precision testing, and percussive and dual rotary drilling.

Jennmar Corp. This multi-national, family-owned company is one the leading providers of ground control technology for the tunneling and mining industries. Some of the company's products and services include Expanbol/Python for ground control applications.

David R. Klug was installed as the new chair of the UCA of SME, replacing outgoing chair Brenda Bohlke.

Together with Keystone Mining Services, Jennmar can tailor its Arch Systems technology for most applications by offering cutting edge steel, reliable moment connection design, computerized engineering requirements and technical support. Keystone Mining Services and Jennmar's goal is to use existing and new products and advanced ground control engineering to improve mine safety and productivity.

Lovat. Lovat custom designs, services, refurbishes, modifies and manufactures a line of tunnel boring machines. The Toronto, Ontario-based company's markets include the construction of metro, railway, road, sewer, water main, penstock, mine access and telecommunications tunnels.

Lovat specializes in rock (single and double shield), soft ground (EPB and nonpressurized) slurry and mixed face TBMs, ranging from 1.5 to 14 m (5 to 46 ft) in diameter. The company's TBMs are versatile and built to the most rigorous safety and quality standards. And Lovat says it is the only tunneling equipment maker that designs, manufactures, assembles and tests under one roof.

Mining Technologies International Inc. MTI is a major manufacturer and supplier of consumables and capital products to the mining and construction industries, including inspection and repair services. The Ontario-based company operates primarily in the underground segment of the mining and construction industries. It has a network of manufacturing facilities throughout Canada and sales and service centers worldwide.

MTI is a multinational company that can service most all development and production equipment in the underground construction and mining industries. Its highly regarded line of consumable products are augmented by an internationally recognized line of capital equipment, including rock drills, and shaft and raiseboring equipment. MTI's customer base includes many of the major mining and tunneling companies worldwide.

Ruen Drilling Inc. Ruen Drilling offers drilling services throughout the United States, South America and Asia. Some of those services include core drilling for geotechnical, mineral exploration and mining companies. The company, based in Clark Fork, ID, provides surface, underground and horizontal directional core drilling services. Its equipment includes trucks, track and modern wireless core drills. Rig capacities are up to 2,745 m (9,000 ft) vertical or angle and 600 m (2,000 ft) horizontal. The company's drillers are also experienced in the installation of instrumentation for geophysical testing.

A few Ruen Drilling's recent projects include the Devil's Slide tunnel the Irvington tunnel and the Caldecott 53 tunnel, all three located in California. Other projects include the Route 9 tunnel in Hong Kong, Highway 53 tunnel in Puerto Rico, White Sands Missile Range in New Mexico and the Mt. Olympus pipeline project in San Diego, CA.

Future meetings

There are a handful of upcoming conferences and exhibitions underground space professionals should want to attend.

The UCA of SME's George A. Fox Conference is scheduled for Jan. 26, 2010 at the Graduate Center, City University of New York, New York, NY. On June 21-23, 2010, the UCA of SME will also put on its North American Tunneling Conference. This biennial conference will be held at the Marriott Waterfront Hotel in Portland, OR. And the next RETC is scheduled for June 19-22, 2011 in San Francisco, CA.

For more information on these meetings, contact the UCA of SME, 8307 Shaffer Parkway, Littleton, CO 80127, phone 800-763-3132, 303-948-4200, e-mail meetings@smenet.org, Web site www.smenet.org.

In addition, the International Tunneling & Underground Space Association (ITA) will hold its annual conference May 14-20 in Vancouver, British Columbia. For information, contact the ITA at phone +41-21-693-23-10, e-mail secretariate@its-aites.org, Web site www.ita-aites.org. ■

EXECUTIVE COMMITTEE

UCA Division installs new officers and committee members

David Klug was installed as the 2009 chair of the Executive Committee of the Underground Construction Association (UCA) of SME during the committee's meeting at the Rapid Excavation and Tunneling Conference (RETC) in June 2009. He will serve a two-year term. Jeff Petersen is vice chair of the committee and Brenda Bohlke became past chair.

Robert Goodfellow and Lester Bradshaw Jr. were also seated on the Executive Committee during RETC.

David R. Klug — Chair

David R. Klug is president and owner of David R. Klug and Associates and president and owner of KSL Construction Systems, both in Pittsburgh, PA. David R. Klug and Associates provides international and national manufacturer representative services to the underground heavy civil and mine construction industries. The company specializes in the coordination of products and specialty services for the New Austrian Tunneling Method, soft ground, precast segmental and conventional tunnel construction. This is inclusive of initial support systems, final lining reinforcement products, connectors and gasket sealing systems for one pass tunnel linings, tunnel profiling and scanning services, specialty design and supply of material handling system and complex final lining forming systems. KSL Construction Systems is a distribution company that services the underground heavy civil and mine construction industries. The company markets specialty products, such as engineered reinforcement and geotechnical and support products used in underground construction. Klug has a B.S. in business management from West Liberty State College in West Virginia. He began his career as a salesman with the National Mine Service Co. and later worked for Commercial Shearing, and its successor companies, a supplier of tunnel support systems in Youngstown, OH. In 1998, he formed Klug Associates and KSL.


KLUG

Klug Associates is a member of the Constructors Association of Western Pennsylvania, a Pittsburgh affiliate of the Association of General Contractors.

Jeffrey P. Petersen — Vice Chair

Jeffrey P. Petersen is vice president of Kiewit Construction Co. in Omaha, NE, a subsidiary of Kiewit Corp. He also serves as district manager for Kiewit's nationwide underground contracting operations. Petersen is responsible for the overall planning and direction of construction, engineering, estimating, bidding and administration of all work for the Underground District.

Petersen joined Kiewit in 1988 after receiving his construction engineering degree from Oregon State University. He began his career at Kiewit's operations in the Pacific Northwest, serving as project engineer, superintendent, project manager and sponsor on numerous jobs, including some of Kiewit's largest and most challenging projects.


PETERSEN

Petersen became a member of The Moles in 2006.

Lester M. Bradshaw Jr. — Committee Member

Lester M. Bradshaw Jr. is president and treasurer of Bradshaw Construction Corp. in Ellicott City, MD. He received B.S. and M.S. degrees in civil engineering from the Georgia Institute of Technology and an M.B.A. from Harvard University. Bradshaw began his tunneling career in 1968 with Eastern Tunneling Corp. He served the company as a tunnel miner, crane operator, surveyor, engineer, project manager and controller. After earning his M.B.A. at Harvard Business School, he spent a year as a senior financial analyst at the corporate headquarters of Standard Oil of Indiana. Shortly thereafter, he helped found Bradshaw Construction Corp. (formerly L. M. Bradshaw Contracting) as its vice president and treasurer. His duties included chief engineer-estimator, safety officer and financial manager.


BRADSHAW

In 1991, he became president

EXECUTIVE COMMITTEE

and treasurer. Bradshaw has overseen the construction of more than $200 million of tunnel construction throughout the Eastern United States and Puerto Rico. In addition, Bradshaw has been the managing partner of several joint ventures building major tunnels and shafts in the southeastern United States.

Bradshaw is a member of the American Society of Civil Engineers, the North American Society for Trenchless Technology and the National Utility Contractors Association.

Robert J.F. Goodfellow — Committee Member

Robert J.F. Goodfellow is associate vice president for Black & Veatch Corp. in Gaithersburg, MD.

GOODFELLOW

He received B.S. degrees in civil engineering and engineering rock mechanics from the Imperial College of London University in the United Kingdom. He is a professional engineer in Virginia, New York, Maryland and Washington, DC and a chartered engineer in the UK.

Goodfellow 's experience has focused on risk management and the technologies of tunneling and underground structures. Projects include design and construction of transportation and water systems in New York, Chicago, Washington, Boston, Seattle, Cincinnati, Cleveland, San Juan, Los Angeles, London, Copenhagen and Hong Kong. His design experience includes analysis, design, 2D and 3D numerical analysis and technical oversight for all types of underground construction. This includes tunnel boring machines, the New Austrian Tunneling Method, cut-and-cover tunnels, shafts and underground chambers. His assignments have included the Niagara Falls Tunnel, the King County Regional Water and Sewer Program in Seattle, WA, the East Side Access Project, the Long Island Railroad Extension in New York City and the River Mountains Tunnel No. 3 in Las Vegas, NV.

Goodfellow is a member of the British Tunneling Society. He has served as session chair and organizing committee member for the North American Tunneling Conference and he was a session chair for the 2005 Rapid Excavation and Tunnel Conference. ■

CALL FOR NOMINATIONS

UCA seeks nominations for the 2010 Executive Committee

The Underground Construction Association (UCA) Division seeks recommendations and nominations from UCA members for interested individuals to serve on the 2010 UCA Executive Committee. The UCA bylaws allow a 19-person Executive Committee. The members of the executive committee are made up of three officers, chair, vice chair and past chair, and four directors from each of the following areas: engineers, contractors, owners and suppliers. Ideally, the UCA Executive Committee has balanced representation from the four categories, but the committee has the option to have more members serving in one or more categories with fewer representatives in others.

If you would like to nominate someone for consideration, please e-mail your recommendation to Mary O'Shea, oshea@smenet.org, at SME headquarters by Nov. 1, 2009. SME staff will compile all nominations for the UCA Nominating Committee's consideration. Please identify in which of the four areas the individual should be considered for service — engineer, contractor, owner or supplier. Also include a brief biography or résumé outlining the person's industry experience and service to UCA and other professional organizations.

Please remember that the individual must be a member of the UCA of SME. ■

2010 CALENDAR

Submit your photos for the UCA calendar

Do you have great tunnel project photos? The UCA Division is asking for photos for its 2010 calendar, which will be available to all UCA members. The best 12 photographs will be selected, one for each month, and credit will be given to the photographer. Please send your high resolution photos to Mary O'Shea at oshea@smenet.org by Oct. 1, 2009. The final photos will be selected by October 30th.

We want to see your work. If you have any questions, please e-mail Brenda Bohlke at bbohlke@myersbohlke.com. ■

October 2009

08-09, 58th Geomechanics Colloquy 2009. Salzburg Congress Center, Salzburg, Austria. Contact:OeGG, e-mail salzburg@oegg.at, Web site www.oegg.at/events/geomechanics-colloquy.

December 2009

01-03, STUVA TAGUNG '09, Hamburg, Germany. Contact: STUVA, e-mail info@stuva.de, Web site www.stuva.de.

March 2010

17-19, The International Symposium on Tunnel Safety and Security (ISTSS) 2010, Frankfurt, Germany. Contact: Andres Lonnermark, SP Technical Research Institute of Sweden, phone 46-10-516-56-91, e-mail andres.lonnermark@sp.se, Web site www.sp.se/en/units/fire/news/ISTSS2010.

May 2010

- **2-7, NASTT'S No-Dig 2010,** Renaissance Schaumburg Hotel & Convention Center, Schaumburg, IL. Contact: Michelle Magyar, Benjamin Media, Inc., 1770 Main St. P.O. Box 190, Peninsula, OH 44264-0190, phone 330-467-7588, fax 330-468-2289, e-mail mmagyar@benjaminmedia.com, Web site www.nodigshow.com.

- **114-20, ITA-AITES 2010, World Tunnel Congress and 36th General Assembly,** Vancouver Convention Center, Vancouver, Canada. Contact: Congress Secretariat, WTC 2010, National Research Council Canada, 1200 Montreal Road, Building M-19, Ottawa, ON K1A 0R6, Canada, phone 613-993-0414, fax 613-993-7250, e-mail wtc2010@nrc-cnrc.gc.ca, Web site www.wtc2010.org.

June 2010

12-19, North American Tunneling Conference, Portland, OR. Contact: Meetings Dept., SME, 8307 Shaffer Parkway, Littleton, CO 80127, phone 800-763-3132 or 303-948-4200, fax 303-979-3461, e-mail sme@smenet.org, Web site www.smenet.org.

May 2011

- **21-26, ITA-AITES 2011, World Tunnel Congress and 37th General Assembly,** Finlandia Hall, Helsinki, Finland. Contact: ITA-AITES, c/o EPFL GC D 1 402, Station 18 CH-1015 Lausanne, phone 41-21-693-23-10, fax 41-21-693-41-53, e-mail secretariat(at)ita-aites.org, Web site www.wtc11.org.■

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

Atlas Copco launches new scaling rig

Atlas Copco has launched a new version of its Scaletec scaling rig giving operators a stronger and faster scaling tool for mining and tunneling applications.

The new Scaletec LC from Atlas Copco is based on the Scaletec MC.

In addition to the standard four-cylinder, Tier III, low-emission diesel engine, the rig is also available with a six-cylinder version that enables faster tramming between sites.

"Our customers have asked for a fast-tramming scaling rig," said Mathias Edhammer, product manager Boltec/Scaletec, Atlas Copco. "With the six-cylinder engine, you increase your tramming speed climbing ramps by almost 50 percent on average."

Other features on this version have been further improved on both Scaletec models, such as the ergonomically designed, FOPS-approved operator's cabin. It features the single seat concept that allows the operator to switch between scaling and tramming mode in one movement.

In addition, the cabin's lift- and tilt-function gives excellent visibility during scaling. A 375-mm (14.75-in.) vertical lift and a 15° tilt provide a superior overview of the working area from the same spot.

The patented boom design helps to improve the visibility and this, combined with its mechanical parallel holding system, makes scaling faster, easier and more accurate.

For a stable setup, Atlas Copco has integrated the front hydraulic jacks on the shovel blade. "By doing this we have placed the support in front of where the boom is attached, instead of behind," said Edhammer. "This gives much better stability and reduces the movement in the cabin."

Atlas Copco's new scalling rig.

www.atlascopco.com

Tunnel Engineers Directional Software being used at Belfast project

Morgan Est., a provider of infrastructure services across the public and private sector in the United Kingdom, has decided to use The Tunnel Engineers Directional Software System (TEDSS) as the laser guidance system for its tunnel alignment control at its mulit-million dollar contract to upgrade Belfast's sewer system for Northern Ireland Water.

TEDSS is owned by Alignment Surveys Ltd. and is a result of many years of development and testing in the field by the company's principal, E.W. Janes.

The TEDSS system can be used for a tunnel project affected by the tight alignments and also for more conventional alignments. Thus, it offers a complete tunnel guidance system in any environment.

In two systems of tunneling, pipe jack and fixed lining, the use of "new technology" gyros for azimuth (heading) information will benefit tunnel boring machine (TBM) operations by reducing downtime caused by system guidance failures and TBM survey checks. Additionally, the reduction of manual survey checks and "survey control" advance within the cramped environment of both tunnel types will also enhance the safety standards of TBM operations.

The rate gyros used for TEDSS are laser gyros. They are compact and more reliable than mechanical gyros, providing greater accuracy with the consumption of less power. These are for use as a stand-alone unit within a pipe jack environment or as part of an integrated system, incorporating a robotic total station, for use within conventional mechanized tunneling. ■

www.alignmentsurveys.com

UCA of SME

www.uca.smenet.org

MEMBERSHIP APPLICATION

Society for Mining, Metallurgy, and Exploration, Inc.
8307 Shaffer Parkway
Littleton, Colorado 80127
(303) 973-9550 (800) 763-3132
Fax: (303) 948-4265 E-mail: membership@smenet.org

_ _ _ _ _ _ _ Last Name: ______

☐ Approved Do NOT Write In This Space

↑ FOR OFFICE USE ONLY ↑

I Am Applying for (check one):

☐ **Admission**
☐ **Change of Status**
☐ **Reinstatement** *(not applicable to students)*

If Reinstatement:
Last Year of Active Membership: ______
Year of Election: ______
Previous Member Grade: ______

Membership Category* (check one):

☐ **Individual Professional Member**
Please complete pages 1 and 2

☐ **Corporate/Sustaining Member**
Please complete pages 1, 2 and 3

☐ **Student Member**
Please complete pages 1 and 2

Membership Dues:

Individual Professional Member:	**$135 per year (+)**
(+) Entrance Fee:	$20
or (+) Reinstatement Fee:	$10
Corporate Member:	**$750 per year**
Sustaining Member:	**$1500 per year**
Student Member:	**$30 per year**

Prefix: ☐ Mr. ☐ Mrs. ☐ Ms. ☐ Dr. ☐ Male ☐ Female

(PLEASE PRINT)
Name: ______
Last First Middle Initial

Company Name: ______
School Name (if student)

Present Position Title or Major (if student): ______

E-Mail Address: ______ Birth Date: ______

Business or School Mailing Address

Street or PO Box: ______

City: ______ State/Province: ______

Country: ______ Zip/PC: ______

Phone: ______ Fax: ______

Home Mailing Address

Street or PO Box: ______

City: ______ State/Province: ______

Country: ______ Zip/PC: ______

Phone: ______

Preferred Mailing Address: ☐ Home ☐ Business/School

Membership Qualifications

UCA INDIVIDUAL PROFESSIONAL MEMBER

A person eligible for election or transfer into the class of Individual Professional Member shall be either: (i) employed in a position of responsibility in an area relevant to minerals exploration, extraction, production, processing, economics or metallurgy, including employment as an educator, engineer, scientist (including chemistry or any related earth science) management (including but not limited to chief executive officer, financial, legal, or human resources personnel); or (ii) hold a baccalaureate degree, masters degree or doctorate degree in engineering, mineral economics or any related earth, chemical or environmental sciences; or (iii) employed or educated in mineral exploration, extraction, production, processing, economics or metallurgy; or (iv) actively involved, directly or indirectly, with mineral exploration, extraction, production, processing, economics or metallurgy, whether through engineering, scientific, related earth science, management, executive, financial, legal, or human resources experience; or (v) engaged in marketing or technical sales of equipment and supplies used in mineral activities.

If at any time your record of experience and/or education is questioned for qualification of member grade, you may be requested to provide an endorsement for membership by an SME member in good standing.

UCA STUDENT MEMBER

A person eligible for election into the class of Student Member must be a full-time college undergraduate or graduate student in good standing. A Professional Member who subsequently returns to school for an additional degree cannot become a Student Member. All Student Members must be nominated by an existing Member.

UCA CORPORATE/SUSTAINING MEMBER

UCA of SME Corporate and Sustaining Memberships are designed especially for companies seeking opportunities to promote their organizations, its services and employees. Any industrial organization in the underground construction industry may become an UCA of SME Corporate or Sustaining Member.

CORPORATE MEMBER BENEFITS — $750

- Two (2) complimentary Professional Memberships
- Complimentary subscription to *Mining Engineering* magazine
- Complimentary subscription to *Tunneling & Underground Construction* magazine
- Membership Directory
- Discounts on all SME publications
- Discounts on SME meetings, conferences and short corses including NAT & RETC
- Link from SME website member page to your company's homepage
- Access to SME comprehensive website

SUSTAINING MEMBER BENEFITS — $1,500

- Five (5) complimentary Professional Memberships
- Complimentary subscription to *Mining Engineering* magazine
- Complimentary subscription to *Tunneling & Underground Construction* magazine
- Membership Directory
- Discounts on all SME publications
- Discounts on SME meetings, conferences and short corses including NAT & RETC
- Link from SME website member page to your company's homepage
- Access to SME comprehensive website

Membership was recommended to me by: ______

Signature (All Applicants)

If elected, I agree to abide by the bylaws and rules of the Society for Mining, Metallurgy, and Exploration, Inc. as the same are now in effect and as they may hereafter be modified while I am a member. I understand that under certain laws and regulations, SME must have my permission in order to communicate with me via fax or email. I hereby give SME Foundation, SME Local Sections and SME business associations permission to send me information and advertisements. If SME does NOT have your permission to communicate with you via fax or email, you may not have access to some of your electronic member benefits.

Signature: ______________________ Date: ______________

Record of Experience

Include most recent record of employment as related to minerals industry.

From: Title: ______________ Employer: ______________

Nature of employer's business: ______________

To: Primary responsibilities: ______________

Position of Responsibility

☐ Yes ☐ No

Education

Please list **highest** degree earned, major, and date of graduation. Student Members must be full-time students at a school approved by SME and must indicate expected date of graduation.

Name of School: ______________

Date of Graduation or Expected Date of Graduation: ______________

Degree Earned: ______________ Major: ______________

Endorsement (Student Members Only)

Student Member applications must be endorsed by an SME Professional Member.

Name: ______________ Member #: ______________ Date: ______________

Divisional/Technical Interest

Please indicate, in order of preference (1, 2, 3), a minimum of one and no more than three, technical interest categories.

Divisions:

- _____ Coal & Energy (F)
- _____ Environmental (E)
- _____ Industrial Minerals (H)
- _____ Mining & Exploration (Metallics) (A)
- _____ Mineral & Metallurgical Processing (B)
- _____ Underground Construction Association (U)

Technical Interest Committees:

- _____ Bulk Material Handling (M)
- _____ Construction Materials & Aggregates (O)
- _____ Education (J)
- _____ Minerals Resource Management (K)

Industry Sector

☐ Underground Construction/Tunneling (11)

Job Title

☐ Consultant (C)	☐ Mine/Plant Manager (N)
☐ Educator (D)	☐ Owner (O)
☐ Engineer (E)	☐ President/CEO/COO (P)
☐ GM/Vice President (G)	☐ Purchasing Agent (R)
☐ Geologist (H)	☐ Scientist/Researcher (S)
☐ Marketing/Sales (M)	☐ Student (T)

Payment

DUES ARE PAYABLE ON A CALENDAR YEAR BASIS.
PAYMENT MUST ACCOMPANY APPLICATION.

Please charge the following credit card:

(check one)

☐ American Express ☐ Discover or ☐ Check Enclosed

☐ MasterCard ☐ Visa Check # ______

Card Number: ______________

Expiration Date: ______________

Signature: ______________

DUES $ ______

ENTRANCE FEE $ ______

REINSTATEMENT FEE $ ______

Dues Payable in U.S. Dollars Only **TOTAL $** ______

Rev. 12/08

CORPORATE / SUSTAINING MEMBERS

Corporate / Sustaining Member Contact Information

Company or Organization: ______

Address: ______

City: ______ State: ______ Country: ______ Postal/Zip Code: ______

Telephone: ______ Fax: ______ Email: ______

Company Representative (Not required to be an SME Member)

Name: ______

Last Name: ______

Title: ______

Telephone: ______ Fax: ______ Email: ______

Corporate / Sustaining Individual Members

Corporate Members are entitled to two Individual Memberships (complete 1 and 2). **Sustaining Members are entitled to five Individual Memberships** (complete 1, 2, 3, 4, and 5).

1. Name: ______

Job Title: ______

Preferred Address: ______

Second Address (optional): ______

E-mail: ______

Busiess Phone: ______

Business Fax: ______

Home Phone: ______

Mobile Phone: ______

2. Name: ______

Job Title: ______

Preferred Address: ______

Second Address (optional): ______

E-mail: ______

Busiess Phone: ______

Business Fax: ______

Home Phone: ______

Mobile Phone: ______

3. Name: ______

Job Title: ______

Preferred Address: ______

Second Address (optional): ______

E-mail: ______

Busiess Phone: ______

Business Fax: ______

Home Phone: ______

Mobile Phone: ______

4. Name: ______

Job Title: ______

Preferred Address: ______

Second Address (optional): ______

E-mail: ______

Busiess Phone: ______

Business Fax: ______

Home Phone: ______

Mobile Phone: ______

5. Name: ______

Job Title: ______

Preferred Address: ______

Second Address (optional): ______

E-mail: ______

Busiess Phone: ______

Business Fax: ______

Home Phone: ______

Mobile Phone: ______

Society for Mining, Metallurgy, and Exploration, Inc.
8307 Shaffer Parkway
Littleton, Colorado 80127
(303) 973-9550 (800) 763-3132
Fax: (303) 948-4265
E-mail: membership@smenet.org

BUSINESS OFFICE
SME - 8307 Shaffer Parkway
Littleton, CO 80127
800-763-3132 • Advertising: x243
Direct: 303-948-4243
Fax: 303-973-3845
www.smenet.org

EDITOR
Steve Kral
kral@smenet.org

SENIOR EDITOR
Bill Gleason
gleason@smenet.org

PRESS RELEASES
Steve Kral
kral@smenet.org

ADVERTISING AND PRODUCTION/ MEDIA MANAGER
Johanna McGinnis
mcginnis@smenet.org

PRODUCTION DESIGNER
Nate Hurianek
hurianek@smenet.org

Tunneling & Underground Construction is supported by leaders in the underground industry. Please patronize them and mention their ad in T&UC.

ADVERTISER .... PAGE NO.

ADVERTISING SALES OFFICES

HOOPER JONES
CENTRAL, NW U.S.
847-486 -1021 • Cell: 847-903-1853 • Fax: 847-486-1025
hooperhja@aol.com

MARSHA TABB
EAST, SOUTH, WEST U.S.
215-794-3442 • Fax: 215-794-2247
marshatabb@comcast.net

LEWIS BONDER
CANADA
514-485-3083 • Fax: 514-487-0553
lbonder@miningpublications.com

PATRICK CONNOLLY
U.K. AND EUROPE
44 1702-477341 • Fax: 44 1702-477559
patco44uk@aol.com

GUNTER SCHNEIDER
SCANDIN. / EUROPE
49 2131-511801 • 49 2131-4038973
info@gsm-international.eu

JOHANNA MCGINNIS
ASIA, RUSSIA, UKRAINE, AFRICA, MID. EAST, LATIN AMER., AUSTRALIA
303-948-4243 • Fax: 303-973-3845
mcginnis@smenet.org

W W W . T U C M A G A Z I N E . C O M