MAY 2010

tunnels & tunneling NORTH AMERICA

Special report: East coast

T&TNA looks at the busy east coast including Miami Port and Niagara Falls

Insight: NAT 2010 preview

A look at what's planned for the North American Tunnelling Conference

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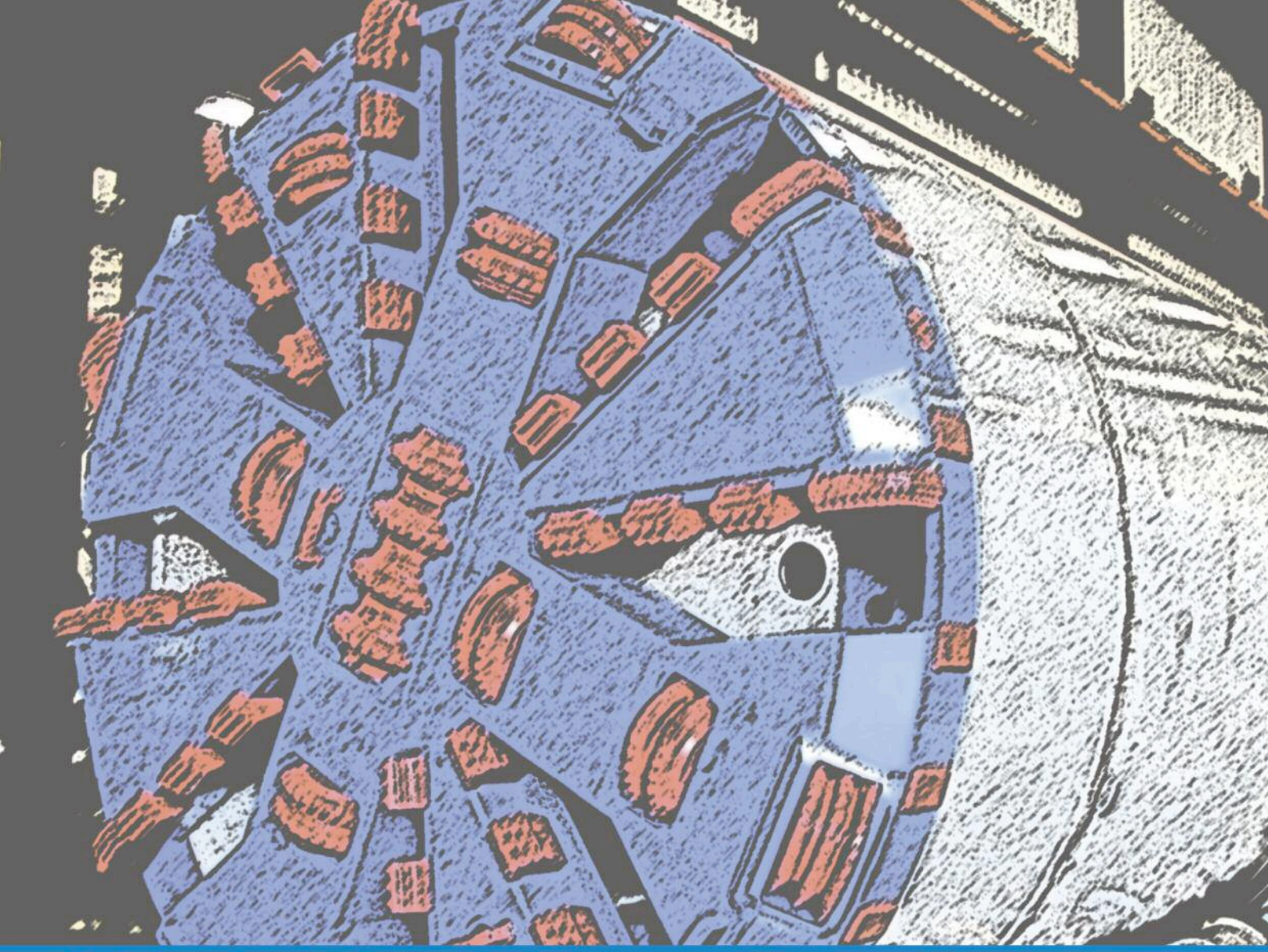

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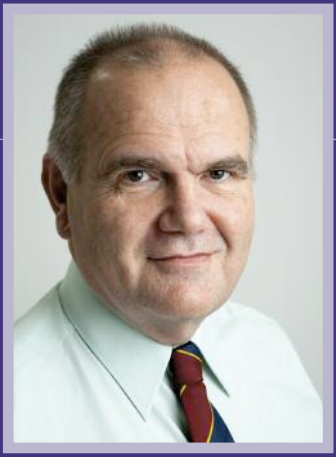

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Telling it like it is.....

The main thing I remember about all previous conferences in North America, and especially NAT, is a refreshing atmosphere of frankness and genuine education. Frankness is not a euphemism for rudeness, or for washing dirty linen in public – far from it. But it does represent a willingness to communicate bad as well as good experiences to fellow tunnellers so that others can learn, be warned, benefit from recommendations or assess things for themselves with the maximum amount of information.

Only in this way can true best practice be achieved to the benefit of all tunnellers. The alternative is knowing only part of the story and so risk getting things partially wrong, and we all know what that can do to a tunneling project.

That is what learned conferences are all supposed to be about, but in other parts of the world they are often blighted by self- or company-promotion, obscuration or poor communication.

It's never too late to learn, despite what youth in general might think, but all over the world it is young graduates that the industry is crying out for to learn about tunnelling. It is no coincidence, we believe, that education and encouragement of graduates to take up engineering, and tunnelling in particular, has been the subject of a recent debate at the British Tunnelling Society and in the guest comment piece in this issue by Randy Essex. The latter was the result of a conversation on another subject with our Nicole Robinson, and is backed up by Randy's work in visiting universities to explain our business and encourage others to take part.

As the north american and, indeed, international tunneling community comes together again for NAT 2010 with its customary enthusiasm for another busy program, it would be good if all taking part could continue in the spirit of open discussion and knowledge transfer.

Unfortunately formal education paths only tell part of the story too, especially when apprenticeship and bursary schemes have broken down through lack of funds. It is at events like NAT 2010 that a fuller picture can be gained from those tunnellers who have themselves learnt from experience and from an earlier generation.

It is those same leading lights of tunnelling who have taken up the slack with, often unpaid, efforts in education and technology transfer. Indeed NAT, was a pioneer with its own short courses and workshops before the main event, directly aimed at filling gaps in essential knowledge. This has become a welcome trend at other conferences and my other national tunnelling societies.

Naive to expect more openness? Maybe, especially when big money may be involved. But it's surely preferable to presenting those who have invested in the event, and especially potential recruits, only half the story.

Of course, as we pointed out in our last issue, T&T North America will be in Portland on 20-23 June, and also at Vancouver for the World Tunnel Congress on 14-20 May, being as open and communicative as ever!

Maurice Jones

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On the cover

CONAGUA, the Mexican water authority, is building the world's largest underground wastewater system at depths of up to 200m. Herrenknecht delivered three EPB Shields (diameter 8,870 – 8,890mm) for a total of approx. 30km of the Emisor Oriente project in Mexico City.

News in brief

PB opens office
USA's Parsons Brinckerhoff opened a new office in North America last month. The company will co-locate with Balfour Beatty Capital, which opened its Canada office last year in Toronto.

Tunnel fire shuts mine
A suspected machine fire 300 metres below the ground in Canada's New Afton Mine's main tunnel shut down operations and put the mine rescue team to work last month. No one was injured.

Toronto subway promise
Toronto mayor Rocco Rossi has vowed to build two kilometers of subway a year for the next decade at a cost of CAD 4.5bn (USD 4.4bn).

Coxwell work starts
Work has begun on a new bypass on Toronto's Coxwell sewer tunnel. The USD 28.3M contract was awarded to McNally Construction in March. (See feature, p16).

NY water tunnel complete
New York's Department of Environmental Protection completed work on boring and instillation of the 8.5 miles (13.67km) of concrete liner in the new USD 6bn City Water Tunnel No. 3.

TBM ordered for Miami

FLORIDA

The TBM for the 1.2km Port of Miami tunnel to the was ordered last month by Miami Access Tunnel (MAT), the private company awarded the contract to design, build and operate the tunnel.

The USD 45M Herrenknecht TBM will be built over the next year in Germany before being shipped in parts to Miami where it will be reassembled at Watson Island to begin boring possibly in the summer of 2011. The USD 1bn project is scheduled for completion in May 2014.

The details were revealed by MAT executive Christopher Hodgkins during a Greater Miami Chamber of Commerce luncheon.

The tunnel will link the port for the first time to area motorways in a bid to speed cargo traffic and ease traffic congestion in the centre of Miami.

The tunnel entrance will be at Watson Island on the median of the MacArthur Causeway which connects to Interstate 395. Hodgkins told the chamber's chairman at the luncheon, "The project is on schedule." (See feature p12).

Low bid for Alaskan Way contract

WASHINGTON

The lowest bid for the SoDo section of the Alaskan Way Viaduct replacement scheme was submitted last month and was nearly USD 40M lower than Washington State's estimate. Skanska USA made the bid of USD 114.6M.

The Department of Transportation (DoT) will award the contract later this month.

The SoDo section of the project, from South Holgate Street to South King Street, features a large interchange that connects the two sports stadiums to the tunnel.

All six bidders for the section were below the state engineers' estimate of USD 153M.

A Skanska spokesperson told *T&TNA* that the firm was hopeful of being awarded the contract.

When complete in late 2013, the south end of the Alaskan Way Viaduct will be replaced with a new side-by-side highway that meets earthquake standards, has wider lanes and improves mobility for people and goods in the Seattle area, said the DoT. It will connect to any future replacement of the viaduct's central waterfront section, including the proposed bored tunnel.

The old south-end section of the viaduct, which is near the sports stadiums, will be torn down in 2012. The central waterfront section of the old viaduct will stay in place until a proposed USD 1bn tunnel is finished through the centre of the city.

Milwaukee completes tunnel extension work

WISCONSIN

Milwaukee Metropolitan Sewerage District (MMSD) has completed construction work on a 3.2km extension of the deep tunnels adding 123M litres of wastewater storage capacity to the underground system.

The cavern, which is 6.4m in diameter and 91m beneath North 27th Street, is the last tunnel segment in district plans. With the completion of extension, total capacity of the deep tunnel system beneath Milwaukee County is 2369M litres - large enough to contain 11 minutes' worth of the flow over Niagara Falls. Californian based joint venture Shea/Kenny completed the construction of the USD65.4M tunnel

In a June 2008 storm, combined sewerage and storm sewers in central Milwaukee and eastern Shorewood spilled 13 billion litres of untreated sewage and storm water into rivers and Lake Michigan. The district would need a tunnel system nearly six times larger than its current capacity to hold all of the overflows that month.

The extension was built to comply with a 2002 state court order requiring USD1 bn worth of upgrades to MMSD facilities to reduce sewer overflows. The tunnels temporarily store sewage and storm water after heavy rains until the treatment plants have space.

In a deluge, combined sewerage and storm sewers in central Milwaukee and eastern Shorewood fill quickly. Leaks of storm water into separate sanitary sewers in other communities boost flows in those pipes up to several times normal daily volumes. Excess wastewater drops into the tunnels until those caverns fill to capacity. When tunnels are closed, overflow from combined sewers is discharged to waterways to prevent sewage backups into basements.

Inspiration against skill shortfall

My son recently graduated from Cornell with a degree in engineering physics. I said, "Why not consider a career in civil engineering, even tunnelling?" He responded "No, dad. You work too hard!"

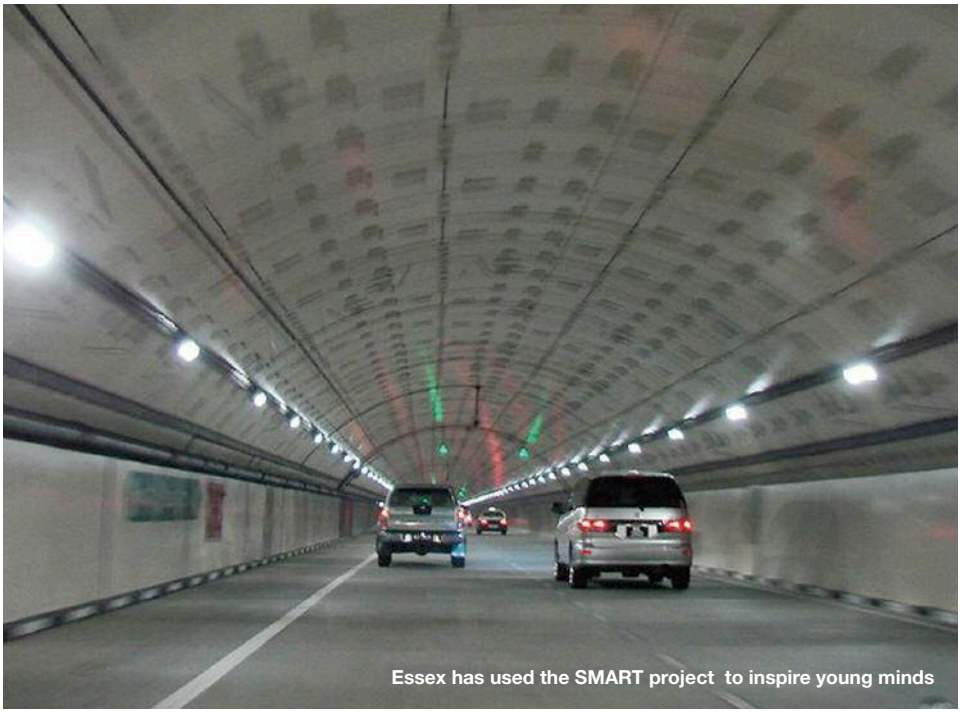
In the North American tunnelling industry there are more projects than there are skilled engineers and tunnellers. Contractors across North America are facing a significant challenge – plenty of work, but too few experienced personnel. The same thing is true in the engineering community.

Our industry is growing at a greater rate than our ability to grow new talent. Young engineers are being given more responsibility earlier, but without the experience to support sound decision-making. They write the reports, prepare the specifications, and create the drawings, but may lack an understanding of what 'constructability' means.

Our ability to attract young engineers to the tunnelling profession is critical to solving this human resource shortfall. It's difficult to pinpoint where this lack of resources comes from. There is a Gen Y component for sure (my wife says I "live to work" while Gen Ys "work to live"). There is also the attraction for bright, young engineers toward computer sciences rather than engineering.

Today, however, we're seeing a shift at the education level. Computer science grads are seeing jobs outsourced to lower labor markets such as India and China. Students are realizing they can't command the higher salaries that have existed with computer engineering. They're starting to look at other forms of engineering—electrical, mechanical and civil. We have a generation of engineering students to inspire.

I spend a fair amount of time at universities talking with undergraduate and graduate students about a career in civil engineering, and more specifically tunnelling. More often than not, a few light bulbs go on, and a student or two will approach me with "I never knew that I could have a career in tunnelling, I've never heard of Hatch Mott MacDonald, and can I have a job?"



Essex has used the SMART project to inspire young minds

The industry needs to do a better job getting the word out that a career in underground engineering—whether it's the civil side or the systems side—is not just about concrete, steel and dirt. We need to do a better job communicating that there are plenty of opportunities for people with mechanical and computerization skills. We have the computing power to visualize complex processes and construction sequences. Life/safety and security engineering demands skills in mechanical engineering and computer simulation. So there is plenty of opportunity to engage the computer-inclined.

When speaking with students, I like to refer to complex tunnelling equipment as Tonka Toys (am I the only one who remembers Tonka Toys?). "Tunnels come in different shapes and sizes. These are the range of ground conditions that Mother Nature has given us, in a rather schizophrenic fashion. Once we (think we) understand the ground, we rely on sophisticated Tonka Toys to help build underground facilities in a manner that keeps the workers safe and overlying structures safe."

It's the details that are so intriguing to these students. I show them stuff that blows their mind—like the SMART (Stormwater Management And Road Tunnel) Project under Kuala Lumpur. We designed a 6.5-mile (10.4-km) tunnel system that mitigates flooding of KL during the monsoon season. But what about the dryer periods? An interior 2.5-mile (4.0-km) section of the tunnel provides double-decker traffic flow under the central business district. When the rain comes, traffic is curtailed, gates open, and the double-decker traffic tunnel transforms into the largest stormwater tunnel in the world. After a rain event passes, the roadway decks and walls are pressure washed, the gates are closed, and traffic flow is restored.

It's an example of taking technology and ideas and blending them to create innovative solutions. When you think about what a 44-ft (13.4-m) diameter Tonka Toy looks like, and what it's helping to build, a young engineer can't help but get excited.

Because Mother Nature is so variable (the term schizophrenic fits well), I sometimes talk to students about being in the business of 'Fooling Mother Nature'. The ground conditions drive the bus. Whether it's a small sewer or a transit station cavern, our technical and contractual objectives are the same – to fool Mother Nature. We get in, build our facilities safely and cost effectively, and then get out. We try to get the job done without Mother Nature ruining our budget or our schedule. It's a challenge. It's a contest.

We need to continue to communicate the dynamic environment of our underground profession. Few students, once exposed, will walk away saying "I won't like this."

Randall (Randy) Essex, executive vice-president and director of tunnels for Hatch Mott MacDonald, was interviewed by staff writer Nicole Robinson

Rerouting Niagara Falls

Left: **Extreme overbreak while boring has led to a new route for the tunnel**

The world's largest hard rock TBM is making good progress in Ontario after the tunnel alignment was changed to avoid high horizontal stresses in the low lying Queenston shale. Bernadette Redfern reports

After a slow start, tunnellers in Ontario are now making 10-15m progress per day on a new diversion tunnel that will propel over 500m^3/s of water into the Sir Adam Beck hydroelectric power station. Client Ontario Power Generation is spending CAD 1.6bn (USD 1.5bn) on the new tunnel, which will allow water from the Niagra River to gravitate to the power station and increase average annual generating capacity by 1.6bn kWh.

"The project is a 10.2km long tunnel from the upper Niagra River to the existing Sir Adam Beck generating station complex, located 8km downriver. That allows us to capture about 96 per cent of the drop between Lake Eerie and Lake Ontario," explains OPG project manager Rick Everdell. "The drop is 100m and we have about 90m head at the hydroelectric station."

To excavate the tunnel the 14.4m Robbins main beam TBM is working from the outfall end and boring back to the Niagra River. The finished diameter will be about 12.7m and will take flows of 500m^3/s of water. "This is a 27 per cent increase on diversion capability over the existing two tunnels that were built in the 1950s. They have a combined capacity of 1800m^3 so we are increasing capacity up to 2300m^3," says Everdell.

Both the US and Canada use flows from the Niagra to drive hydro-power stations. Under the Niagra Treaty of 1950 each country has the right to use an allocated amount of water for power generation per annum. Thanks to the retirement of several Canadian power stations including the Rankine Generating Station, the Toronto Power Generation Station and the Ontario Power Generating Station, Canada was operating under capacity. This, coupled with a drive from state government to eliminate generation from coal fired power, led to the development of the project for a third diversion tunnel to boost hydro generation at the Sir Adam Beck plant. Ontario currently has over 8000MW of thermal power generation including four coal fired plants. This compares to 6,606MW of nuclear energy capacity and 6,963MW of hydro capacity. By 2014 all coal plants will be decommissioned.

Against this backdrop the potential to increase hydro-generation at Sir Adam Beck station was anticipated as far back as the 1980s and environmental approvals for the third tunnel were acquired in the late 1990s. "We started work back in 1982 with a definition and environmental assessment," says Everdell.

The environmental assessment process committed OPG to using a TBM for tunnel excavation and also driving from the outlet end on the Sir Adam Beck property toward the intake so that logistics could be managed from existing OPG property at the power station site - away from the tourist areas. "The two original tunnels were dug using drill and blast and there were five major shafts through the city and a lot of disruption associated with that, which meant we needed a more palatable approach for the 1990s when the EIA was done," says Everdell.

However following environmental approval, progress stalled as the Canadian electricity market underwent a restructuring. This, coupled with a lull in power demand meant that the project was put on hold. But five years later Ontario Power Generation, the new body which had absorbed the original Ontario Hydro Company, decided to pick up the project. A third tunnel was back on the agenda.

Quick launch

"In 2004 a decision was made to proceed with the project which was sat on the back burner. We launched an international competition for a design and build contractor for execution of the tunnel and we also engaged Hatch Mott MacDonald to act as owner's representative," says Everdell.

Four contractors were prequalified for the project which was originally expected to cost CAD 985M (USD 933M). Austria's Strabag was selected in August 2005 and quickly began to mobilise. The team had to make a September 2006 launch date and

had a 4,440t, 14.4m diameter hard rock TBM to build. Although larger diameter TBMs have been used in soft rock this is the world's largest hard rock machine.

"Achieving assembly in 12 months was a critical milestone for a successful start so this meant getting the TBM designed, fabricated, shipped, assembled and launched, which was done in collaboration with Robbins," explains Ernst Gschnitzer project manager for Strabag. This 12 month limit led the team to embark upon a unique solution. "Our manufacturer chose not to pre-assemble the TBM. We shortcut the process by shipping components directly to the site from the UK, Italy, United States and a few pieces from Canada. These pieces had never been matched together so this was a challenge for the mechanical engineers. On top of this we had to merge metric and imperial systems on several components but it went well," says Gschnitzer.

So well in fact that success on this project has led Robbins to use the same approach on other sites where launch schedules are similarly tight. Client OPG was pleased with the fast start. "Actually it was very quick. We mobilised and started site preparation in September 2005, ordered the TBM immediately and assembled it within 12 months," agrees Everdell.

Coping with overbreak

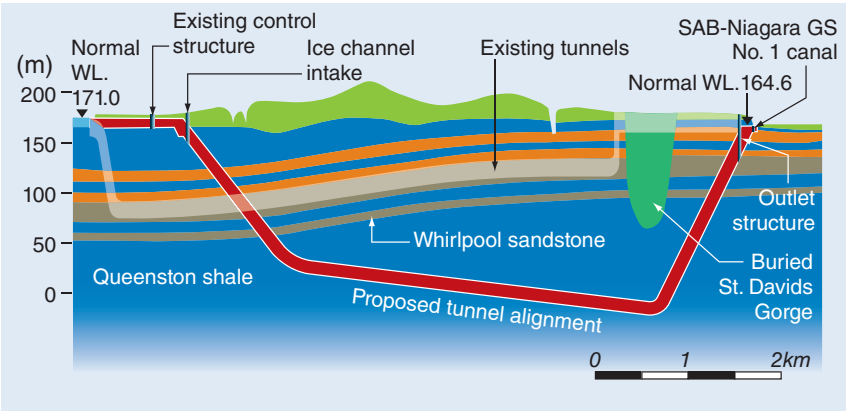
Unfortunately once boring began the team found themselves up against some unexpected ground conditions and progress suffered. High horizontal stresses in the Queenston shale located in the lower strata were leading to overbreak. "The biggest technical challenge was dealing with overbreak. In our case this means a break that exceeds 3m and we sometimes had the equivalent of a long tube above our heads like a 4m tunnel," says Gschnitzer.

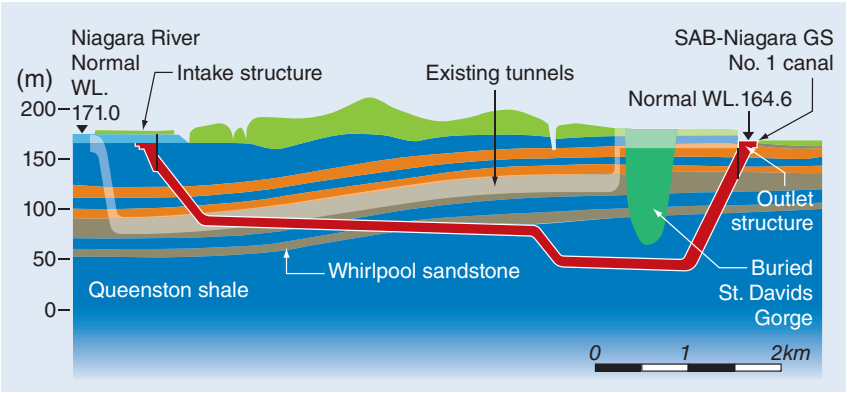
Obviously this meant that the rock support system, which used rock bolts, wire mesh, steel ribs and shotcrete had to be adjusted, as did the methods for installation. "We had to do a series of adjustments and improvements on the rock support system and we had to change the original fixed working platforms. When there is a 3-4m overbreak above the TBM it is difficult to get there to support and prevent it deteriorating. We had to remove the rigid platforms and replace them with telescoping man baskets so that we could support the rock from a safe working area. It was adopting drill and blast methods onto a large scale TBM," explains Gschnitzer.

After losing months to the unexpected overbreaks the team decided that the only way to get the project back on schedule was to change the tunnel alignment. By the end of 2008 the new route was underway. "The main problem area was on the vertical alignment, 140m below surface in the Queenstown shale under the Barry St Davids Gorge (see profile diag), but we changed the alignment such that the tunnel was ramped up to 90m below the surface minimising the amount of remaining excavation in the Queenston shale," says Gschnitzer.

The sandstone above the shale is performing much better and overbreak has been greatly reduced. Strabag is now making 10-15m of progress per day and hit a record of 22m in July 2009. This

Right: The original route of the tunnel and the new route; Below, left and right: Big Becky and the backup is the largest hard rock TBM Robbins have built





Left, top: A section through the orginal tunnel alignment Left, bottom: A section through the new alignment

equated to 468m in a single month. Today the team has completed just over 6.5km of the bore. However the poor ground conditions have cost the team approximately three years and over CAD 600M. "It took us all by surprise. We like to see some horizontal stress to keep your key block in place – but what was surprising to designers on both sides was the amount of horizontal stress and we reached a point where the crown and the invert just continuously crushed by this very high pressure. It was undetected and probably undetectable," says Gschnitzer. "OPG had done an extensive investigation programme over the years and none of these conditions were detected in the rock cores," he says.

Another impact of the Queenston shale was the need for a waterproof lining on the tunnel. It's long term swelling properties make it essential to the tunnels integrity that leakage is prevented. In addition OPG specifications required a 100 year design life. "The combination of swelling properties, 100yr design life and high pressure, which is up to 15 bar in some places, led us to use a 100 per cent waterproof membrane throughout," says Gschnitzer.

The initial shotcrete lining varies in depth from 100mm to 250mm depending on the condition of the rock, but in September 2009 a 25m length of the temporary lining failed, at around 3.5km into the tunnel. Work halted as repairs were carried out and a side effect of this incident was the decision to begin installation of the permanent 600mm cast in situ permanent lining early.

Strabag had already begun pouring the tunnel invert lining to the bottom third of the tunnel with over 4km poured to date. So it was a logical decision to launch the arch positioning equipment early to both save time and provide extra support to the crown. "This is a decision that was made later in the project - to launch the arch form while the TBM is still running to save time on the schedule. We decided to launch it by feeding the essential systems, light ventilation, power and water through the arch form," explains Gschnitzer.

The essential systems are currently connected to the temporary lining so the arch installation system has to be capable of removing these and reaffix them to the new permanent liner. A series of motorised arch carriers that move along ledges cast into the invert liner make up a lining train. This was designed by a Strabag subsidiary BMTI. A team of 20 is currently assembling the system prior to launch in May. It is expected that the whole carrier and concrete pour system will advance up to 25m per day to facilitate placement and curing of 25m of arch concrete lining, using two 12.5m shutters. In total, the arch carrier train is about 450m long, about 12m high and weighs about 1,800 tonnes. "Launching the arch form in May is the next major milestone," says Gschnitzer.

Water ingress

As well as reacting to the challenging ground conditions, the project team has also acted to prevent potential problems before they arise. One of which concerned ingress of groundwater at the Niagra River end of the tunnel. "We are digging 1.5km right under the river and in order to mitigate water inflow we have drill and blasted a tunnel 300m downstream of the river. Around 1000t of cement grout was used to reduce the water inflow to less than 1m/s," says Everdell. "We drilled to the point where we encounter water tight rock to stop the inflow before the TBM gets to that area."

In terms of bore completion, break through at Niagra River is expected in spring 2011. "The cutters are performing very well. We have adopted a 20 inch (508mm) cutter based on a previously used design for a 19 inch (483mm) cutter fitted with a 20 inch ring in order to improve performance," says Gschnitzer.

As for the excavated material the shale is being made available to local brick manufacturers who are hauling this away once the conveyor system has removed it from the tunnel. Any water ingress is being treated to drinking water standard to enable it to then be returned to the Niagra River. "There is also very sophisticated water treatment plant consisting of carbon filters that can deal with anything that might be found - from suspended solids to hydrocarbons," says Gschnitzer.

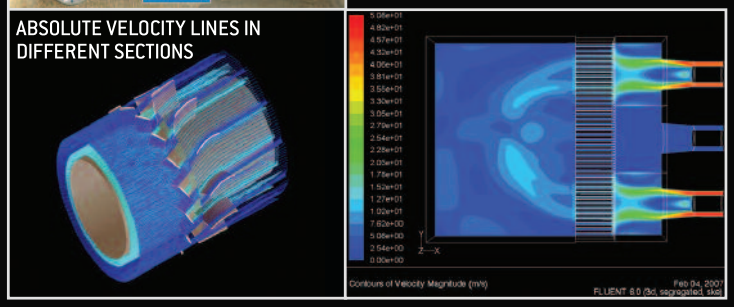
Final project completion is set for December 2013 and it seems that the large number of challenges and issues that the team has overcome has made their working relationship closer. "As we have seen we have overcome a series of challenges and from a contractors perspective we can only successfully do this if you apply a collaborative approach with the client," says Gschnitzer.

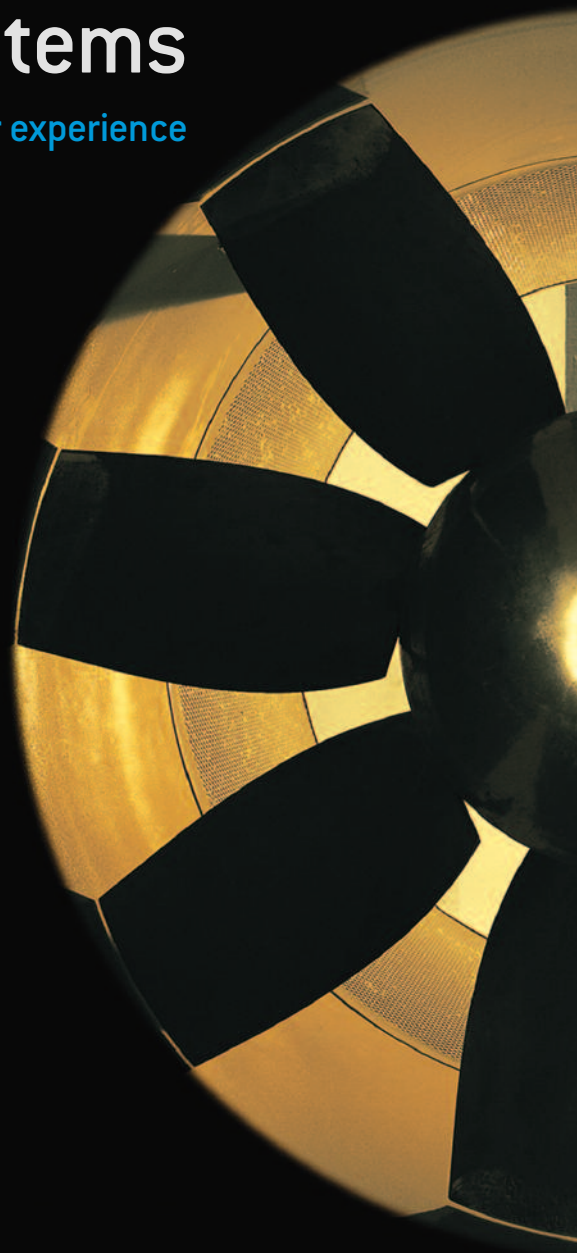
Everdell agrees. "We appreciate the teamwork. Even though the price has risen considerably it is still a very attractive option and one of the lowest cost alternatives for electricity supply compared to other types of generation."

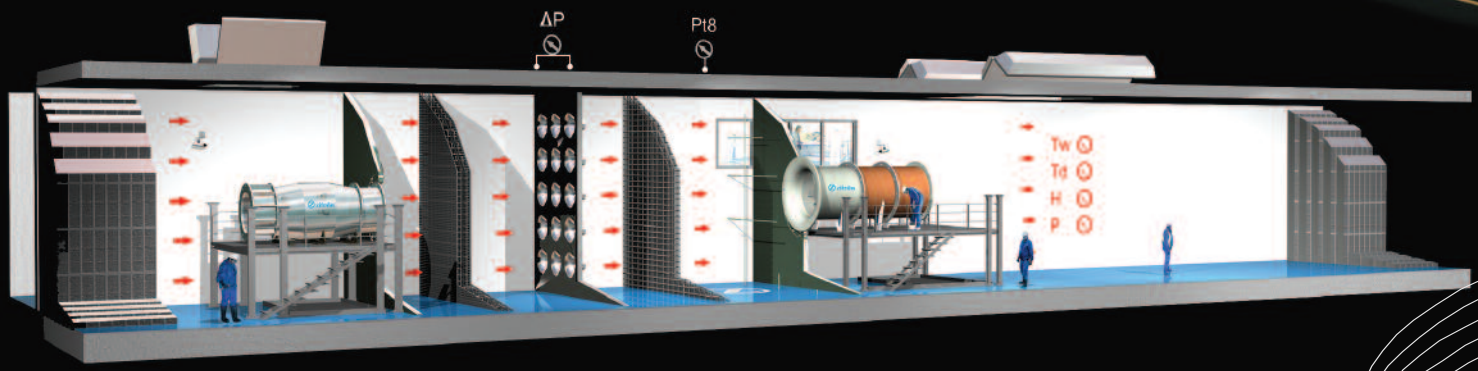
More than ventilation systems

The measure of our experience

Over 40 years of experience, a high degree of technological competence and highly qualified staff endorse our work which is among the most valued and acknowledged in our sector.







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Miami mole

Plans are being refined for construction of the Port of Miami Tunnel, due to start excavation next year. Report by Patrick Reynolds

With excavation for the new twin-tube road tunnel at Port of Miami still a year away, its swathe of client sponsors from state, county and city authorities, and the PPP concessionaire, a venture of Meridiam Infrastructure Finance and Bouygues Travaux Publics, are now focused on the detailed design challenges.

They can also look in the rear-view mirror at the successful financial close for the project, eventually achieved late last year, on 15 October 2009, marking the start of the 35-year concession to serve the cargo and cruise port.

The construction cost is USD 607M plus reserves but little payment will be received by Miami Access Tunnel (MAT) concessionaire, LLC, the vehicle for the leaders of the winning JV, during the development phase. The main payments will begin when the road tunnel comes into service in just under four years, in the second quarter of 2014.

The core of the design, build, finance, operate and maintenance project involves construction of twin bores below the waters of Government Cut between Watson Island to the Port of Miami, on Dodge Island (see map). The eastbound and westbound tunnels are to be 3,693ft (1,126m) and 3,980ft (1,213m) long, respectively.

Other key aspects of the project include widening of the MacArthur Causeway Bridge and connections to the Port of Miami road network, improving links to Miami Beach. Early site work is now underway by Bouygues, which was awarded the contract for the work following the financial close. The contract was signed with Florida Department of Transportation (FDoT), Miami-Dade County and the City of Miami, which also benefited from federal credit input to the entire process.

However, getting this far has neither been simple nor straightforward.

An interrupted journey

The new tunnel has been under consideration since the 1980s as a way to reduce traffic congestion caused by the heavy vehicles making deliveries and collections from the port in Downtown Miami. From the initial studies the merits of a tunnel solution quickly came to be examined, with a variety of alternatives and routes being discussed.

Identified as a prime candidate from among the early alternatives, in 1990 the current alignment was selected as the preferred route – a subsea link that would run below Government Cut, the main, artificial shipping channel in Biscayne Bay. There followed a decade and a half of varied geotechnical studies and planning until the procurement process commenced in early 2006 with a call for groups to prequalify.

Site work is starting to scratch the surface this month while detailed design continues though MAT was named as the winning bidder more than two years ago in February 2008. Tenders had been submitted on schedule in early 2007, the shortlist of bidders having been selected a year earlier.

Unfortunately the project then fell victim to the global financial crisis, which sent shock waves around North America and the rest of the world. At the time MAT was constituted as a JV of Bouygues with the bank Babcock & Brown Infrastructure Fund. They were equity partners but, due to the financial crisis, the bank had difficulties maintaining its significant equity involvement.

Protracted negotiations ensued. The possibility of the planned 2012 completion deadline for the project receded. Eventually, after months of talks, FDoT announced at the end of 2008 that because of the ongoing difficulties it decided it could not to close on the deal. The project was in jeopardy.

At the time Gus Pego, FDoT's District Six Secretary, said: "I applaud our local partners for coming to the table and providing the funding to go forward. However, I also recognise that our private partners are experiencing the effects of these difficult economic times. Although everyone has worked hard to bring this project to fruition, we must face the reality that our private partners have been overwhelmed by the effects of the financial market making delivery unworkable."

Above: **The 1.2km tunnels will pass under the Port of Miami**

But being of such long-term and clear strategic benefit, the project wasn't about to be let go so easily.

A new partner enters

A year after the winning bidder was named efforts to revive the project and find another source of finance were successful and a new equity partner entered the scheme in place of Babcock & Brown. The partner – Meridiam – joined Bouygues in the venture and the arrangement had the equity split shift to

be held mostly by the new partner, which contributed approximately USD 72M.

In mid-2009, FDoT noted that a commercial agreement had been reached and that the next, and final step, would be to progress to financial close. That happened in October, almost to the revised schedule – despite last minute concerns over local funding – and so completed the PPP contract award and saw the concession period begin.

Port of Miami is Meridiam's first investment in North America, and its second involvement in tunnels – the first being the Limerick toll tunnel under development in Ireland. The project includes an immersed tube tunnel below the river Shannon, and the concessionaire aims to open the new road link later this year. The 35-year PPP concession runs to 2041.

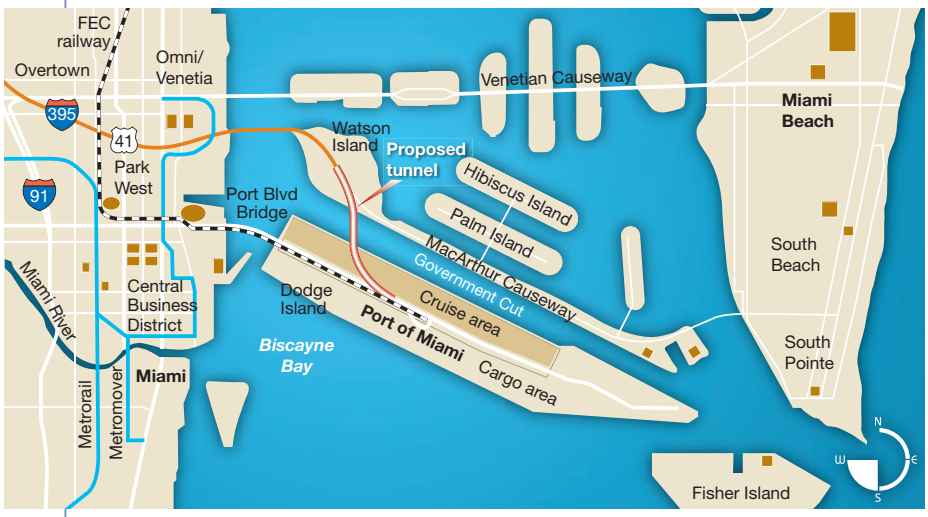
Meridiam notes that its activities benefit from the support of its own sponsors Credit Agricole and Aecom Technology. At the concession signing, county mayor Carlos Alvarez, said: "The Port Tunnel's significance cannot be understated, downplayed or dismissed – particularly in this economic time. As we build it, we will create hundreds of jobs, keep our seaport competitive and transform Downtown Miami."

In structuring the PPP, FDoT was advised in the process by legal firm Nossaman, and the PPP is only the second in the US to use availability payments. Nossaman also advised on the first project to do this, the I-595 Corridor Improvements project also by FDoT.

Design to build

Bouygues Travaux Publics is undertaking the design and construction challenge at the Port of Maimi Tunnel under a contract to the concessionaire, MAT. It is developing the final design for the project with engineering support being provided by Jacobs Civil for both general construction activities and tunnel works.

The tunnel is being designed to cross the shipping channel almost perpendicularly with its ends curving off to tie-in to the existing road alignments on Watson and Dodge islands, giving it a lazy S-shape in plan. Geology along the tunnel alignment



Left: **The proposed tunnel alignment**

sees each end of the bores dominated by a highly permeable soil-like layer of sand with some limestone.

Lower, the majority of the strata that the drives will pass through will be of the Fort Thomson Formation – increasing with depth they are: limestone with sand (2MPa-55MPa with an average of 22MPa); cemented sand with shells (1MPa-37MPa with an average of 8MPa); and, sand with inclusions and interbedded zones of sandstone. They average slightly more than 20 feet (6.1m) in thickness.

The lowest stretch of the drives, below the channel, are expected to shave the top of the Anastasia and Key Largo Formations – sandstone interbedded with sand lenses, zones, seam and occasional sand/silty sand (limesilt) pockets. The UCS values range from 4MPa-36MPa with an average of 17MPa.

With the design still being refined, the latest plan sees the bores being driven below the channel with the crown of the tunnel having minimum cover of 28feet (8.5m) to the sea bed and being approximately 75 feet (22.9m) below the surface water level. The TBM is selected to be 42 feet (12.8m) in diameter and the bores are to be excavated to a maximum depth of approximately 117 feet (35.7m) below the water level.

Six cross passages are to be built at nominal intervals of 600 feet (182.9m)-700 feet (213.4m). The tubes are to be excavated to 15 feet (4.57m) with completed widths of 13 feet (3.96m). One of the passages is to be excavated under the shipping channel and two below the edges of the islands, according to the current layout.

The maximum TBM drive length is estimated to be approximately 3,200 feet (976m) long. Ground treatment plans include soil substitution and reinforcement near the portals and extensive inter-tube strengthening is also required. Plans also include ground treatment such as jet grouting at the cross passages, and the possibility of ground freezing is being considered for the deepest bore that is to be mined below the channel.

Excavation of each bore is expected to take approximately six months, starting around the third quarter of 2011. The TBM is to be launched at Watson Island and on reaching the port, on Dodge Island, it will be turned around and relaunched to drive the parallel tube.

The bores are each to hold two 12 feet (3.65m) wide lanes plus curbs, walkways, ventilation fans and other safety features.

Finance and Procurement

The total financing budget for the Port of Miami Tunnel project is USD 903M, including construction and other costs, such as reserves and financing – the latter totalling approximately USD 195M.

Debt financing for the project totals almost USD 723M. The pool of banks providing almost half as senior debt include BNP Paribas, Banco Bilbao Bizcaya Argentina, RBS Citizens, Banco Santander, Bayerische Hypo, Calyon, Dexia, ING Capital, Societe Generale and WestLB.

The other half of the senior debt funding was provided under a federal facility – the Transportation Infrastructure finance and Innovation Act (TIFIA) programme. In terms of debt repayment on the USD 607M construction cost, the state and local governments have agreed to a 50:50 split.

Equity injected to the venture – USD 80.3M – is being provided to the concessionaire in a 90:10 split between Luxembourg-based Meridiam, through Delaware-registered Meridiam Infrastructure Miami, LLC, and Bouygues, through Florida-registered Dragages Concession Florida, Inc.

FDoT will provide USD 100M for milestone payments prior to completion and acceptance of the road tunnel, which is expected to take 55 months to build. Another USD 350M is earmarked by the state as the final milestone payment on acceptance of the asset, to be paid almost a half year after it's due to come into service in the second quarter 2014.

Starting from Q2, revenues to be received by MAT Concessionaire, LLC, will come through an annual maximum availability payment of USD 32.48M (2009 prices), which will payout fees based on performance and operations. It will then have 30 years of income before ownership of the asset is handed over to FDoT.

In its bid submitted in early 2007, MAT tendered to have a 47-month construction period – eight months shorter than that now given – and to receive an annual maximum availability payment of USD 33.3M, which has only slightly changed.

Rival bids were submitted by two rival groups – Miami Mobility Group and FCC Construccion/Morgan Stanley. Their respective bids were USD 39.75M with a 50-month construction period, and USD 63.25M with a 42-month construction period. Project planners had originally anticipated that the annual availability fee being bid could be up to USD 68M, and so all bids were within the limit.

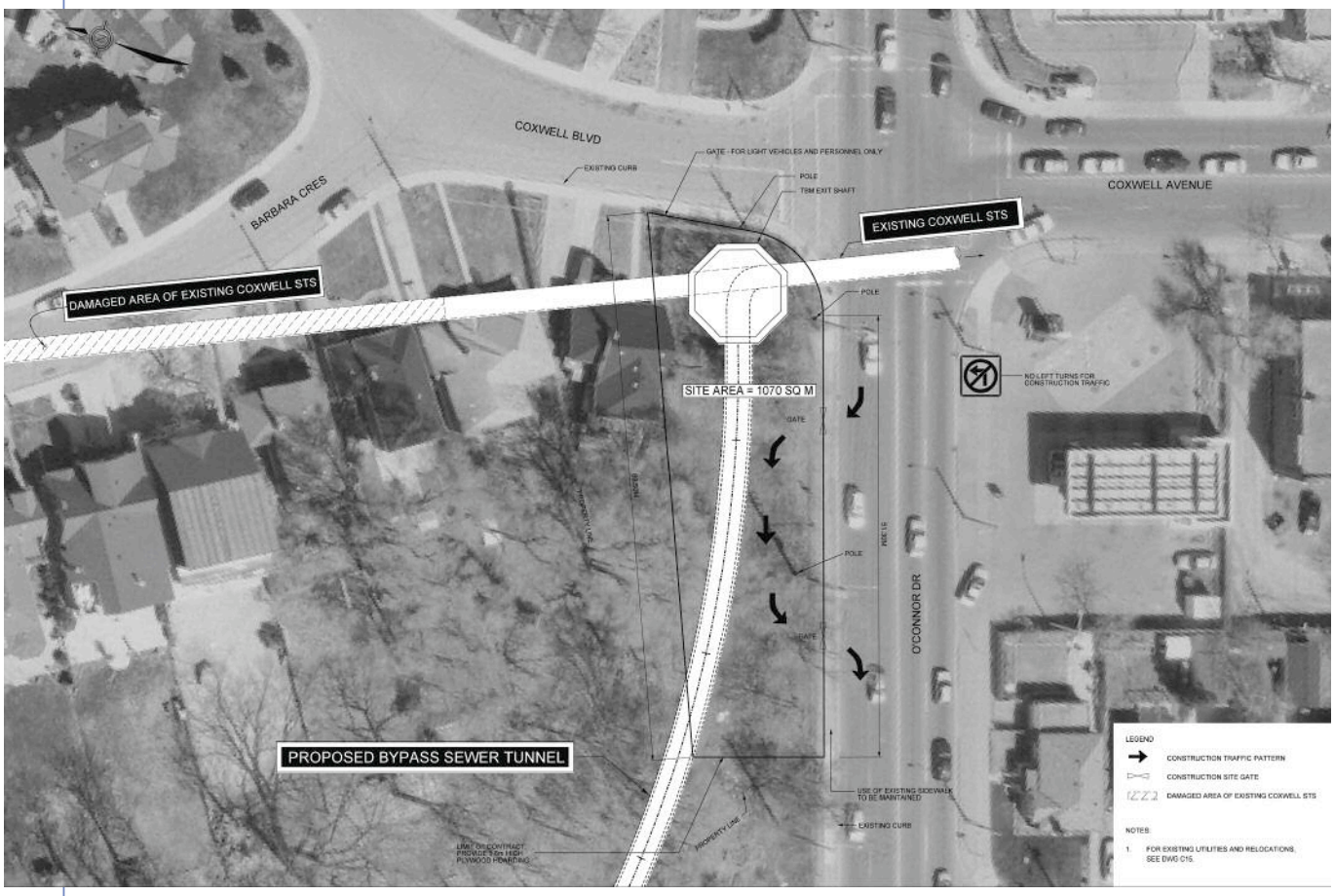
Benefits to come

A long time in planning and development, the link is but the latest chapter in the growth of the port's infrastructure to meet cargo and cruise demand on the waters without the overland arteries choking as they feed the sites overland.

In a pre-financial crisis and recession analysis, the port tunnel project was estimated in a study to be capable of bringing an estimated USD 12bn boost to the economy of Miami-Dade as well as ease the traffic problems in Downtown Miami.

Strategic expansion of the port area has been undertaken systematically and relentlessly over many decades, important to maintaining its global leadership position in serving container and passenger vessels. Even the financial storm that buffeted the port wasn't enough to stop the tunnel being pursued.

In about a year, though almost two years later than previously envisaged, the TBM – the Miami mole – should finally start digging.



Bypassing a cracked sewer

A tight radius curving EPB drive will eliminate a major sewer collapse risk in Toronto Canada reports Adrian Greeman

The City of Toronto has been bit uneasy for the last 12 months. Its largest sewer line, the Coxwell Sanitary Trunk Sewer, which collects together the flow from three main sewers in north Toronto, has got cracking and other signs of damage in a part of its upper section.

Monitoring of flows upstream and downstream, ground settlement and other observations, have been carried out by the City since the problem was detected and so far the tunnel has performed as normal. But there is always the fear that the damage might cause failure or blockage. This is no small matter in a 2.6m diameter tunnel which is the city's most critical trunk route to the treatment works, carries a peak dry weather flow of 6m3/sec.

The existing tunnel runs for 4.8km to the Ashbridges Bay Treatment Plant along the side of the river valley, through a reasonably well built up residential area. There is no means for the flow to be diverted and so a new 510m tunnel has just started construction which will take the foul waters on an arcing curved diversion around the damaged section, rejoining the old tunnel line further down the Don River valley.

The original tunnel was dug by hand excavation within a shield using compressed air in the late 1950s. Design standards at the time did not include provision for inspection and maintenance access points more than every 1.5km. Combined with the depth of the tunnel and the relatively high flows, this had ruled out any inspections until recently.

But in late 2008 the city began an inspection programme as part of an overall waterfront clean up scheme and sent closed circuit TV into the sewer followed by a robotic inspection

in November. These revealed heavy roof cracking of the original concrete lining in a 60m length of previously inaccessible tunnel.

The new section around this will be a segment lined drive by EPB machine cutting through glacial tills and waterlogged sands. Tunnel depth will be up to 420m, largely because of topographical changes along the relatively steep valley side; the tunnel slope itself is no more than a 1per cent gradient.

The arcing route of the diversion has been set by the City client paying attention to the need for easements. It runs primarily through parkland and city land rather than underneath houses and private land although two properties are affected.

Initially the city looked at seven different options including a drive through underlying hard rock and five for the softer ground above. The soft ground was the more sensible for the impact on residents, cost and speed of construction. Final tendered alignment and outline design was produced for the city by consultant Hatch Mott MacDonald.

That means the design and build contractor for the project must cope with some fairly tight radius curves on the tunnel line. Other challenges are the fairly high water table in the ground and the need to connect into the live sewer eventually.

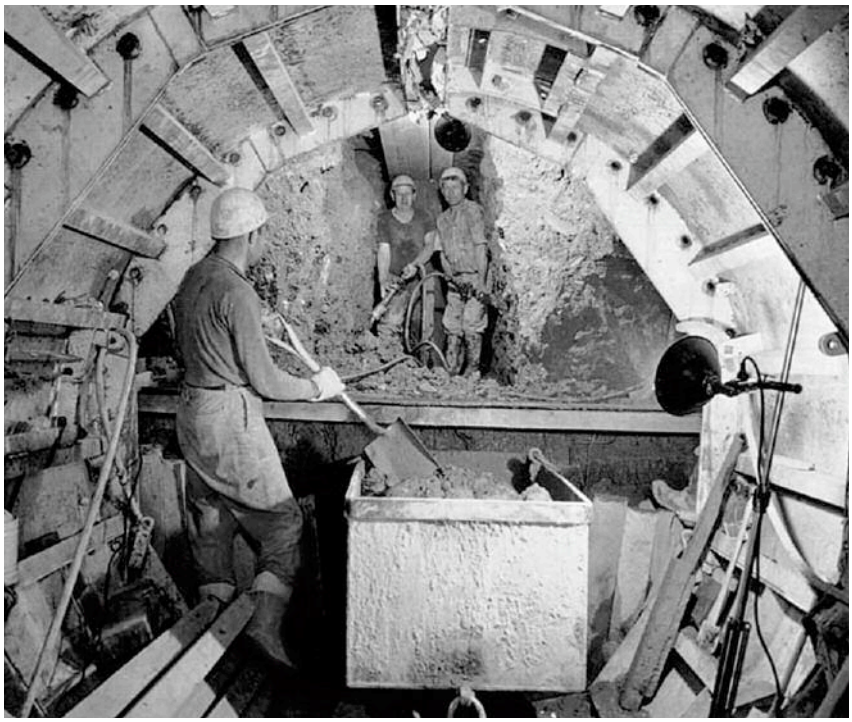
Geology of the valley is primarily a glacial silty sand, underlying a alluvial and fill layer of around 3m. Deeper down is a hard rock though it has no effect on the project.

"The main material is a fairly firm till known as Halton Till, and is pretty commonplace throughout the city area" says Derek Zoldy, design engineer for consultant Aecom Canada on the design/build contract, working for contractor McNally which was awarded the work in March. "There is some chance of boulders as in most till but the machine should be able to handle that." A number of additional boreholes are being finished currently to improve the detail of the geology.

Options for the tunnel included dewatering or EPB methods, and McNally opted for the machine drive. The firm has a fair amount of experience using EPB even though it is a relatively late arriving technology in Canada, where other methods have proved more economical in the past. This is perhaps surprising considering major TBM maker Lovat is Canadian.

"We have been doing a lot of this work recently to the north of Toronto, on the York region's Nineteenth Avenue tunnel scheme"says Steve Skelthorn, the British-origin project director for the work "and are well experienced".

Below: **A view down the original sewer construction**



One of three 3.3m external diameter machines used for those contracts is coming to the Toronto project but only after a stop-off at Lovat where it is being reconditioned and modified, with new articulation in the tail section. This will help the machine to negotiate the two 150m radius curve sections on the drive. Internal diameter required for the tunnel is 2.744m.

"There are a couple of straight sections and two 150m lengths with a tight curve on them," says Skelthorn. Tightest curve on the last job was a 250m radius which needed only the head articulation.

He does not anticipate any great issues handling the tighter curves but it does impose additional effort. "Trying to get your bigger pieces of machinery around a tighter curve can be awkward and they tend to want to climb up the wall a little and rotate. You can also find the mucking conveyor on the machine does not sit properly over the muck cars". Mucking out will be by electric battery powered 10t Greenborough locomotive and cranes at the end shaft.

The till spoil will need to be dumped because it will have been treated with foams and polymers to achieve a consistent cut for the machine. The area is well provided with disposal areas and a number of disused gravel pits looking for fill material so this should be no problem. A Ministry of the Environment approved landfill east of the city is the most probable.

A particular issue is likely to be guidance of the machine, not because of any difficulty as such, but simply because it will need to be brought forwards every few segments installed. "We are using a Zed laser guidance system and will have to bring that up every three of four segments" says Skelthorn. On the previous job it would need moving every twenty to 40 segments."That does mean checking your positioning more frequently and we shall need a full time surveyor on this tunnel." On most other jobs a single surveyor can look after two or three tunnels on a visiting basis, he says.

The segments have been modified in design for the tunnel, also because of the tight curves. As previously the lining will be a six segment precast concrete ring, a modified universal ring with six rhomboid segments and two trapezoidal, the key and counter-key. "We have slightly enlarged the counter-key relative to the key which makes fitting easier," says Skelthorn "and it reduces the size of the ram stroke".

Thickness of the segments was still in

design stage as *T&TI* went to press, with a fibre reinforced and a cage reinforced option being assessed. Fibre would require around 200mm and cage a little more.

For past jobs McNally has made its own segments. Canada has few off-the-shelf suppliers like Charcon because of the relative infrequency of EPB methods and segmental lining in general in the past.

For the Coxwell job it is subcontracting segment production to a local concrete firm, Munroe Precast. "In fact we are buying and will own the steel moulds and will supply the accessories and steel ourselves," says Skelthorn. "The contract is rather for them to make and place the concrete." A quality assurance inspector from the contractor will keep an eye on the output.

Since the job is not such a large one, Skelthorn says that a relatively relaxed single 10 hour shift pattern will be sufficient. An experienced workforce is not hard to find, with most of the work crew moving on from the former contracts northwards. "But Toronto has seen substantial tunnel activity for decades and there is a good experienced workforce here."

There will be a learning curve inevitably but it should be short he thinks. All this is to come however over the next 10 months. Right now McNally is concentrating on site preparation and early work at the two end shafts fore the drive.

First of these is in a carpark serving a local parkland area, Taylor Creek Park. Here the contractor needs to built a 20m deep starter shaft for the machine and to access the original tunnel to make a diversion structure.The shaft will be done with secant piling and will be almost rectangular in plan 2m by 10m wide. It will have a dividing wall to separate the tunnel starter pit for the drive from the adjacent work on the old sewer. "On the far side we will be installing a flume in the old sewer," says Skelthorn. The steel diversion has inflatable end inserted into a broken open section of the sewer to seal it and divert the flow. Obviously the work has to be timed for moments of low flow in the gravity sewer.

Once in place the old tunnel can be broken out and new diversion structure built ready for the eventual connection.

The first problem to solve is getting the heavy equipment to the new site. Access is via a road running under a nearby highway, and the bridge underneath has only 2.6m clearance; the road has to be lowered for the drilling rig and TBM parts. Environmental rules have to be monitored for the site too and the contractor is coordinating with the Toronto Conservation Authority, the Department of Fisheries and the Ministry of Natural Resources to make sure it complies.

Above: **The 2.6m diameter EPBM will cut through glacial tills and waterlogged sand**

At the other end of the project there is a smaller diameter shaft needed but with a greater depth, to 40m. This will need to go through sandier ground which is mostly water saturated. To seal the ground the shaft will be made with a 750mm thick bentonite slurry wall excavated using a big Bauer machine. The panels will form a hexangonal shaft 10m across.

The base of the shaft is being sealed with jet grouting. Reasonable care will be needed for this as the city owned area for the compound is not large and there are properties close by. Subcontractor Petrifond out of Montreal will do the wall and Hayward Baker the jet grouting.

There is fair amount of interest in the project by the residents and by users of the park area at the top end of the site; so public relations is an important part of the job says Skelthorn. Completion is scheduled for January 2011 at which point Toronto's residents will be able to breathe a sigh of relief that the collapse risk has been eliminated.

NAT 2010 Portland, Oregon

All eyes are on Portland, Oregan as it prepares to host the North American Tunnelling Conference (NAT) next month. The conference, run every two years, always draws a crowd with its impressive offering of technical papers, workshops and exhibits. And this year is no exception.

The usual short courses and workshops will be held on the Sunday covering grouting, shafts, specifications and legal issues. Portland Mayor Sam Adams will open the conference on Monday, June 21. Over 100 presentations are currently due to be given across four track topics: Technology, Planning, Design and Case Histories.

Alongside the congress is the accompanying exhibition, which has already sold out - with nearly 100 national and international companies taking booths at the show. Industry sponsorship of the social events has also once again been popular and as well as the Icebreaker Reception, Congress Luncheon, and Exhibit Hall Receptions each day, there will also be an Awards Banquet.

Categories include a Lifetime Achievement Award, Outstanding Individual Award, Outstanding Educator Award and Project of the Year. The Student Scholarship Competition has become a regular feature at the NAT. This year's papers are on Tunnelling: Sustainable Infrastructure. The three finalists will present their papers at the Conference Luncheon and the winner will be announced at the Banquet.

The Conference is also offering field trips on the final day of the event. On Wednesday afternoon attendees can visit the East Side collections system overflow tunnel project being constructed by Kiewit/Bilfinger Berger joint venture with a 7.6m diameter Herrenknecht slurry mixshield, or can take a tour of the Portland Area Works Progress Administration tunnels from the 1930s and 1960s.

NAT 2010 Topics

- Tunnel Boring Machines
- Ground Conditioning and Modification
- Equipment Automation
- Conventional Tunneling
- NATM/SEM & Caverns
- Small Diameter Tunneling
- Shaft Construction
- Emerging Technologies
- Lining Design & Precast Segment Advances
- Fire & Life Safety
- Vulnerability & Security
- Seismic Design
- Updating Design Criteria
- Tunnel Management/Inventory
- Rehabilitation
- Cost Estimating & Scheduling
- Financing
- Public Policy
- Contracting & Payment
- Alternative Delivery Methods
- Insurance & Bonding
- Third Party Liability
- Labor Management & Training
- Case Histories

Sunday, June 20, 2010

7:00am	**Short Course Registration**
8:00am - 4:00pm	**Short Courses:** *Grouting in Underground Construction* *Soft Ground Tunneling* *Shaft Design and Construction*
9:00am - Noon	**Workshop:** *Better Specifications for Underground Projects: Perspectives of Owners, Engineers, Contractors and Suppliers*
	Short Course: *Shaft and Tunnel Blasting*
9:00am - 5:00pm	**Exhibitor Registration**
1:00pm - 4:00pm	**Workshop:** *Professional Liability Issues for Consulting Engineers on Tunnelling Projects: Perspectives of Owner, Constructor and Consulting Engineer*
2:00pm - 4:00pm	**NAT Organizing Committee Meeting**
2:00pm - 5:00pm	**Attendee Registration**

Monday, June 21, 2010

7:30am - 8:30am	**Authors' Coffee**
7:30am - 5:00pm	**Registration**
9:00am	**Welcome Chair: Mark Ramsey Keynote**
10:30am	**Sessions**
Noon	**Luncheon*** *Luncheon Speaker: Richard S. Staples "Tunneling in Canada: Past, Present & Future"*
1:30pm	**Sessions**
5:00pm - 7:00pm	**Opening Reception/Ice Breaker & Poster Session Exhibit Hall**

Tuesday, June 22, 2010

7:00am - 8:30am	**UCA of SME/ITA Breakfast***
7:30am - 8:30am	**Authors' Coffee**
7:30am - 5:00pm	**Registration**
8:30am	**Sessions**
11:00am - 2:00pm	**Exhibits & Poster Session**
Noon - 2:00pm	**Exhibit Hall Luncheon**
1:30pm	**Sessions**
5:00pm - 7:00pm	**Reception, Exhibit Hall**
7:00pm - 10:00pm	**Awards Banquet*** *Speaker: Dr. Scott Burns*

Wednesday, June 23, 2010

7:00am - 8:30am	**ISDT Breakfast***
7:30am - 8:30am	**Authors' Coffee**
7:30am	**Registration**
8:30am	**Sessions**
11:00am - 2:00pm	**Exhibits & Poster Session**
Noon - 2:00pm	**Exhibit Hall Luncheon**
Noon - 4:00pm	**UCA of SME Executive Committee Meeting**
1:00 - 5:00pm	**Field Trip*, East Side CSO Tunnel Project**
	Field Trip*, Portland Area WPA Tunnels
	**ticketed event*

Exhibitor guide

As with any trade show, making the most of your time is often about getting yourself around the show efficiently. With much of the time at the North American Tunnelling Conference spent in technical sessions and workshops this guide should make sure you know where your key clients and contacts are.

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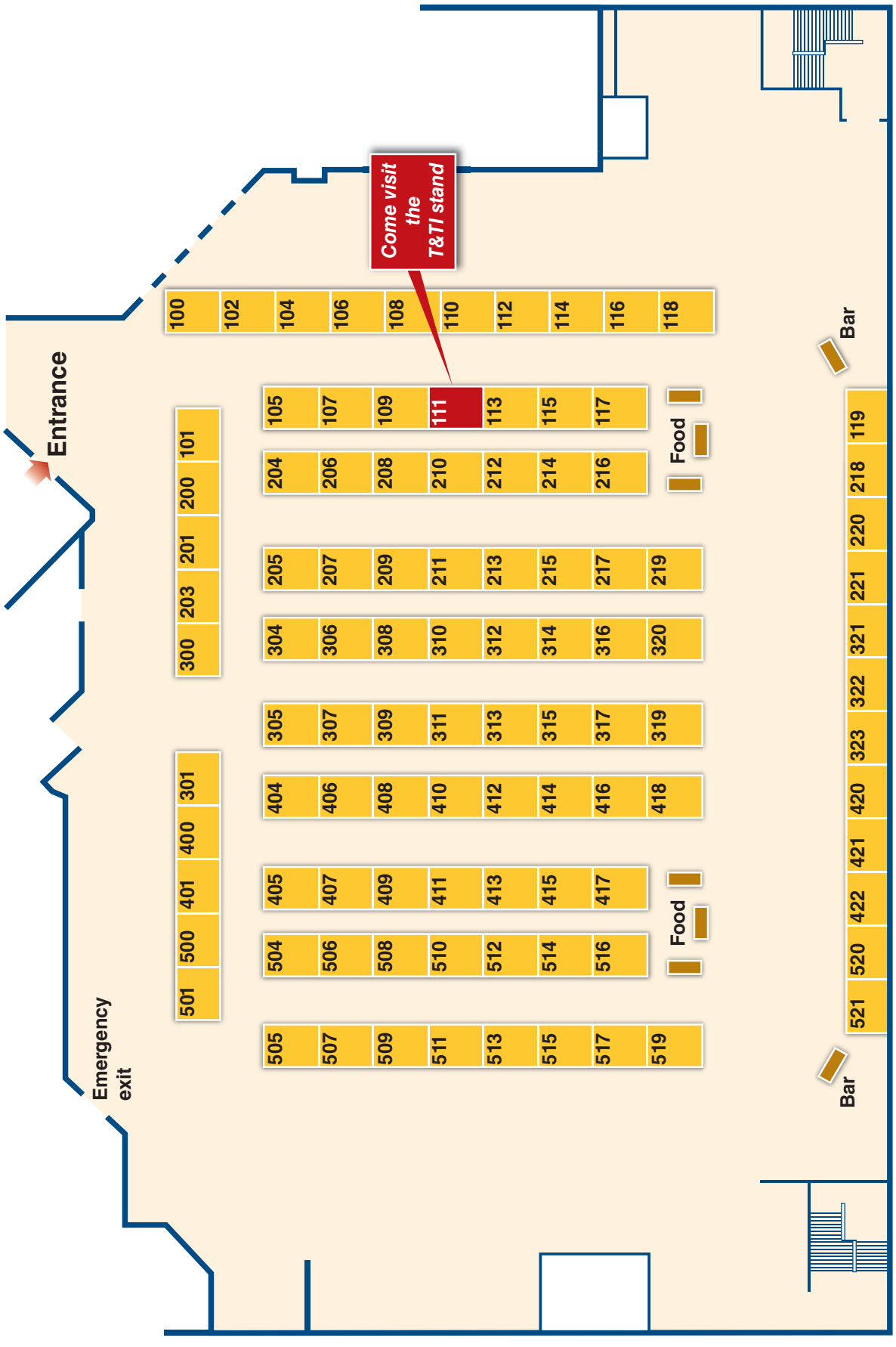
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June 19 – 23, 2010

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- Equipment Automation
- Conventional Tunneling
- NATM/SEM & Caverns
- Small Diameter Tunneling
- Shaft Construction
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- Fire & Life Safety
- Vulnerability & Security
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- Third Party Liability
- Labor Management & Training
- Case Histories

For additional information on exhibiting, sponsorship or general inquiries, contact:

SME, Meetings Dept.

Phone: 303-948-4200

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NAT Programme

	Technology	Planning	Design	Case Histories
Monday, June 21 10:30am	**Innovation**	**Project cost estimating/finance**	**Design**	**Small diameter**
Chairs	E. Bier, Mining Equipment, Albuquerque, NM C. Heinz, Kenny Construction, Chicago, IL	D. Louis, MTACC/URS Corp., New York, NY	S. Swartz, Jacobs Associates, Seattle, WA	J. Brady, Lachel Felice & Associates, Atlanta, GA
	Onsite, First Time Assembly of TBM's: Merging 3D Digital Modeling, Quality Control, and Logistical Planning	Size Matters If You're a Tunnel	Instrumentation of Freight Tunnel in Chicago	Microtunneling Challenges: Crossing Under Major Railroad and Highways in Very Soft Glacial Soils – The Evolution of a Ground Treatment Assessment Process:
	Large Diameter Segmentally Lined Shafts	Setting the Owner's Budget: A Guideline	Field Mapping and Photo Documentation of the Southern Nevada Water Authority's Lake Mead Intake No. 3 Project, Saddle Island, NV	Marysville Trunk Interceptor Project: A Case History
	Large Diameter TBM Development	Show Me the Money: The Real Savings in Tunnel Construction Payment Provisions	Tunnel – Induced Surface Settlement on the Brightwater Conveyance East Contract	Innovative CSO Pipe Installation in a Congested Urban Setting
	ADECO as an Alternative to NATM: 22m Wide, 14m High Full Face Tunnel Excavation in Clays	Planning Level Tunnel Cost Estimation	Strategic Tunnel Enhancement Programme, Abu Dhabi, UAE: An Overview of Geology and Anticipated Geotechnical Conditions Along Deep Sewer Tunnel Alignment	Pipe Jacking Through Hardpan
	Cutter Instrumentation System for Tunnel Boring Machines		Geotechnical Variability and Uncertainty in Long Tunnels	Construction Challenges for Small Diameter Soft Ground Tunnels
	Towards Precise Under Ground Mapping System on Canada			
Monday, June 21 1:30pm	**Pressurised face tunnelling**	**Project delivery**	**Challenging conditions and site constraints**	**NATM/SEM**
Chairs	C. Lawrence, Hatch Mott MacDonald, New York, NY	R. Beck, TJPA, San Francisco, CA	D. Dobbels, Haley & Aldrich, Boston, MA	B. Zernich, Traylor Brothers Inc., San Diego, CA
	Lake Mead Intake No. 3 Tunnel: Geotechnical Aspects of TBM Operation	Lake Mead Intake No. 3, Las Vegas, NV: A Transparent Risk Management Approach Adopted by the Owner and the Design-Build Contractor and Accepted by the Insurer	New Irvington Tunnel Design Challenges	Past and Present Soft Ground NATM for Tunnel and Shaft Construction for the Washington, D.C. Metro
	Continuous Conveyor Design in EPB TBM Applications	Tunneling MegaProjects: They Are Different	The Sunnydale CSO Tunnel: Dealing With Urban Infrastructure:	The Lincoln Square Tunnel: Tunneling Between Two Parking Garages Using Sequential Excavation Mining
	International Practices for Connecting One Pass Precast Segmental Tunnel Linings	Alternative Contracting and Delivery Methods:	New York Harbor Siphon Project	Complex Design and Construction of Tunnel and SOE to Accommodate Challenging Site Conditions
	Geotechnical and Design Challenges for TBM Selection on the ICE Tunnel	Design of the Waller Creek Tunnel, Austin, Texas	Rehabilitation of Rail Tunnels With Widening the Cross – Section While Maintaining the Regular Rail Traffic	
	Soft Ground Tunneling on a Mexico City Wastewater Project	Tunneling as PPP-Project: Risks From the Viewpoint of the Insurer on a Case Study of a Tunnel Collapse	Development of Seismic Design Criteria for the Coronado Highway Tunnel	
	Small Diameter Tunneling – Ems-Dollard Crossing	DCWASA's Project Delivery Approach for the Washington, DC CSO Program		
		How to Deliver Your Project on Time: An Owners Procurement Strategy		

Tuesday, June 22 8:30am	Applied technology	Project planning and implementation I	Managing risk, safety, and security through design	Challenging conditions
Chairs	D. Ofiara, The Robbins Co., Solon, OH	G. Davidson, Jacobs Associates, Seattle, WA	J. McKelvey, Black & Veatch, Indianapolis, IN	M. Vitale, Hatch Mott MacDonald, Cleveland, OH
	Deep Inclined Water Intake Shafts	Sustainability Drives Jollyville Transmission Main Tunnel Design	Performance – Based Design Using Tunnel Fire Suppression	Tunneling on Brightwater West
	Construction of the Railway Bosphorus Tube Crossing, Tunnels and Stations	Sustainable Underground Solutions for an Above Ground Problem	First Comprehensive Tunnel Design Manual in the United States	New York City Transit No. 7 Subway Extension Underpinning and Construction Under the 8th Ave. Subway
	Ground Freezing Challenges for Horizontal Connection Between Shafts Under Difficult Geologic and Hydrostatic Conditions	Large Diameter TBM Solution for Subway Systems	Geotechnical Investigations for the Anacostia River Projects	Consolidation of the Riverbank Filtration Tunnel
	Final Lining at Devil's Slide Tunnel	Digging Deep to Save Green While Being Green		Gotthard Base Tunnel: Micro Tremors and Rock Bursts Encountered During Construction
	The History of Tunneling in Portland: Rail, Highways, and the Environment	Design and Construction Considerations for Shafts and Grand Central Terminal for the MTACC's East Side Access Project		Optimization in Blasting Production and Vibration Mitigation for Shaft and Tunnel Construction at Lake Mead
	San Vicente Pipeline Tunnel: A Sophisticated Ventilation System	The Urban Ring Project: Planning a New Bus Rapid Transit Tunnel for Boston		
Tuesday, June 22 1:30pm	**Tunnel lining and remediation**	**Project risk/Budget/Schedule**	**Managing risk, safety, and security through design**	**Challenging conditions**
	D. Pease, Traylor Brothers, El Cajun, CA	D. Penrice, Hatch Mott MacDonald, San Francisco, CA	S. Zlatanic, Parsons Brinckerhoff, New York, NY	D. Dobbels, Haley & Aldrich Inc., Boston, MA
	High Pressure Concrete Plug Leakage Remediation	Blast and Post Blast Behavior of Tunnels	Lining Design Issues Associated with the Storage of Cryogenic Fluids in Rock Caverns	A Conventionally Tunneled River Undercrossing
	Structural inspections of Colorado's Eisenhower Johnson Memorial Tunnel, Hanging Lake Tunnel and Reverse Curve Tunnel	Decision – Making Case History for Municipal Infrastructure Improvements	Design Guidelines for Sequential Excavations Method (SEM) Practices for Road Tunnels in the United States	Tunneling Ground Reinforcement by TAM Grouting: A Case History
	Corrosion Protected Systems for Tunnels and Underground Structures	Risk Management to Make Informed Contingency – Based CIP Decisions	Continuum and Discontinuum Modeling of Second Avenue Subway Caverns	The Construction of the Tunnels and Shafts for the Project XFEL (X-Ray Free Electron Laser)
	Lined Concrete Segments: An Alternative Construction Method for Large Diameter Sewer Tunnel	Linear Schedules for Tunnel Projects	Shaft, Cavern, and Starter Tunnel Construction for Lake Mead Intake No. 3: Temporary Support and Permanent Lining Solutions	Canadian Fast-Track Drill and Blast: Excavating the Rupert Transfer Tunnel at James Bay, Quebec, Canada
	Portal Slope Stability and Tunnel Leakage Remediation	Building Mined Underground Stations in Soft Ground With NATM Construction Practices	Methodology for Structural Analysis of Large-Span Caverns in Rock	Re-Design of Water Tunnels for Croton Water Treatment Plant, New York City
	Inspection and Rehabilitation of Heroes Highway Tunnel In Connecticut	Cost and Schedule Contingency for Large Underground Projects: What the Owner Needs to Know		Keys to Success in Managing a Complicated Tunnel Project: City of Columbus – Big Walnut Sanitary Trunk Extension, Part 6F1
		Overhead and Uncertainty in Cost Estimates: A Guide to Their Review		Drop Structures and Division Structures for the East Side Combined Sewer Overflow Project: Portland, OR
Wednesday, June 23 8:30am	**Sustainability**	**Project planning and implementation II**	**Design optimization and alignment selection**	**Operational criteria functionality for highway tunnels**
	G. Clemens, American Commercial, Louisville, KY	L. Dwyer, Parsons Brinckerhoff	G. Klein, URS Corp., Oakland, CA	No information available as T&TNA went to press
	Sustainable Tunnel Linings – Asset Protection That Will Not Cost the Earth	Sedimentary Rock Tunnel for CSO Storage and Conveyance in Cincinnati, OH	Factors Influencing Tunnel Design in Mass Transit Applications	
	Design for Sustainable and Economical Tunnels	Tunneling to Preserve Tollgate Creek	Transbay Transit Canter Program Downtown Rail Extension Project	
	Sacramento UNWI Sections 1 and 2 Project: Special Tunnel Construction with Plastic-Lined PCC Segments	Tunneling Under Downtown Los Angeles	A Tale of Two Capitals: Modeling Helps Designers Manage Strong Surge and Pneumatic Forces in Deep Combined Sewer Storage Tunnels	
	Sustainable Underground Structure Design	Selecting an Alignment for the Blacklick Creek Sanitary Interceptor Sewer Tunnel – Columbus, OH	McCook Reservoir Main Tunnel Connection Marks Another Significant Milestone in Chicago's TARP	
	Use of Underground Space in a Pristine Watershed, Chester Morse Lake Pump Plant and Intake, North Bend, WA		Integration of Operations and Underground Construction: Sound Transit University Link	


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