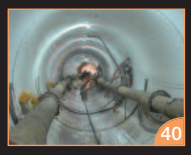
AUGUST 2010

tunnels & tunnelling INTERNATIONAL


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Special report: North America

T&TI explores tunnelling work on the West Coast and checks in on the progress of New York's East Side Access

Technical: Jacking

T&TI looks at jacking pipes and other structures to create underground space

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Illumination breakthrough

A look at Europe's first tunnel with LED linear lighting



CHINA: FIRST LARGE DIAMETER YELLOW RIVER CROSSING ACCOMPLISHED.

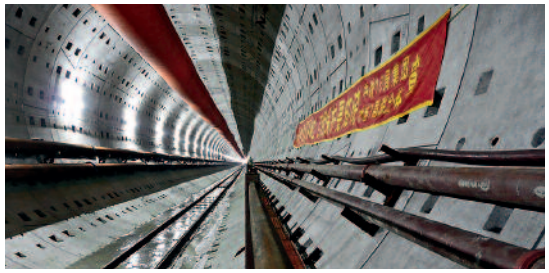
The reowned South-North Water Diversion Projekt in China consists of Western, Eastern and Central routes. The Yellow River Crossing Project ist the key junction of the entire Central route, with a total length of 19.3 kilometers, channeling the water from Danjiangkou Reservoir to Beijing, Tianjin and other northern China areas. Along the Central route, two 4.25 kilometer-long parallel tunnels cross under the Yellow River in order to connect the water channels of both river sides. 3.45 kilometers of each tunnel are built with maximum overburden of 36 meters beneath the river, while the rest of 800 meters Mang Mountain Tunnel is constructed with a designed gradient up to of 49.1‰.

Herrenknecht provided 2 Mixshields (Ø 9.0m), named as "Yellow River" (S-358) and "Traverser" (S-359), to construct these large-diameter crossing tunnels in the Central route. The "Traverser" reached its target shaft successfully on the 22nd, June, 2010, achieving a best weekly rate of 115.2 meters. The "Yellow River" is planned to finish its excavation in October 2010. Their common success will contribute significantly to the operation of the Central route in 2014.

ZHENGZHOU | CHINA

PROJECT DATA	CONTRACTOR
S-358, S-359 **2x Mixshield** Diameter: 9,000mm Cutterhead power: 1,100kW Tunnel length: 2x 4,250m Geology: Pebbly sand, medium grained, coarse clay	Joint Venture of China Railway 16th Group and Sinohydro Bureau 7, Joint Venture of China Railway Tunnel Group and China Gezhouba (Group) Corporation Client: Construction and Administration Bureau of South-to-North Water Diversion Middle Route Project

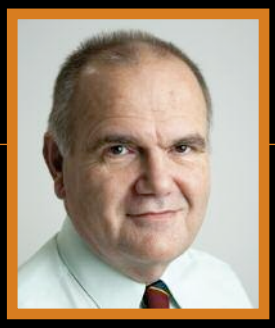




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HERRENKNECHT
Tunnelling Systems



contents

comment

Safety concern or sensation?

When are three collapses on the same tunnelling project not a sensation? When you are the mayor of Prague apparently.

Last month's collapse during construction of the Blanka Tunnel Complex for the Prague ring road was the third reported since 2007, and yet the owner's first real reaction, represented by Mayor Pavel Bem, was to blame journalists of 'sensationalism', whereas the more sobre assessment would be on their reflection of the legitimate concerns of citizens. (See World News p5 and In Depth p14 this issue) As is usual when politicians are under pressure, especially in an election year and when intimately involved with a particular project, the media makes an easy target as a distraction from the real story. And Mayor Bem is certainly under pressure, for safety reasons now as well as for the cost of the longest city tunnel in Europe and the most expensive construction project ever undertaken in Prague.

Before Tunnels & Tunnelling International attracts the likely accusations of some readers of not supporting the tunnelling industry by concentrating on bad news, or of the sin of speculation, let us say that, as a professional journal team, we are committed to finding the facts of what went wrong. In the absence of hard facts it is legitimate to assess likelihoods and to ask questions, as any investigation will do with, hopefully, greater resources than ours.

And there are plenty of questions to be asked, some of which the contractor Metrostav has already speculated upon in an official statement. These could include:

1) As the tunnel cover ranges 8-44m on this project, was the working depth too shallow, at least for the type of support and construction method chosen?
2) Since it has been said frequently that certain geological conditions were unexpected, should there have been more site investigation?
3) Was the construction design faulty, and what was the real role of engineering designers and project managers to date, as Metrostav has to field most of the questions?
4) Should there have been additional ground stabilisation measures, especially near major structures?
5) Was there a human error in removing needed support, or on the part of supervisory management or advisors?
6) Were there any more than legitimate cost-saving measures in the tunnel support and safety inspections, as some leaked reports have indicated, and that a critical auditor no longer works for the city?

The official investigation seems unlikely to report for 2-3 months. The many investigations into collapses under NATM procedures, SEM or similar procedures have confirmed that close supervision of support, and support removal, procedures is essential. In the meantime, the fear of the unknown could well turn people against tunnelling, especially in urban situations.

What is needed is practical and rapid steps that may reassure the public, voters and guardians of city resources that tunnelling can and should be carried out safely under such circumstances. Rightfully the Czech mining authorities have stopped all but safety-essential work on the tunnel to carry out investigations, but more is needed to prevent a PR disaster, second only to BP's, for Europe's biggest urban tunnel project.

Ultimately, we may hope for some clear answers away from the fog of politics.

PS A joke doing the rounds is that the latest collapse is hole 3 on the mayor's golf course. Nothing like humour to satirise a bad situation.

Maurice Jones



On the cover

T&TI looks at the LED linear lighting of the recently refurbished Vlake Tunnel in the Netherlands

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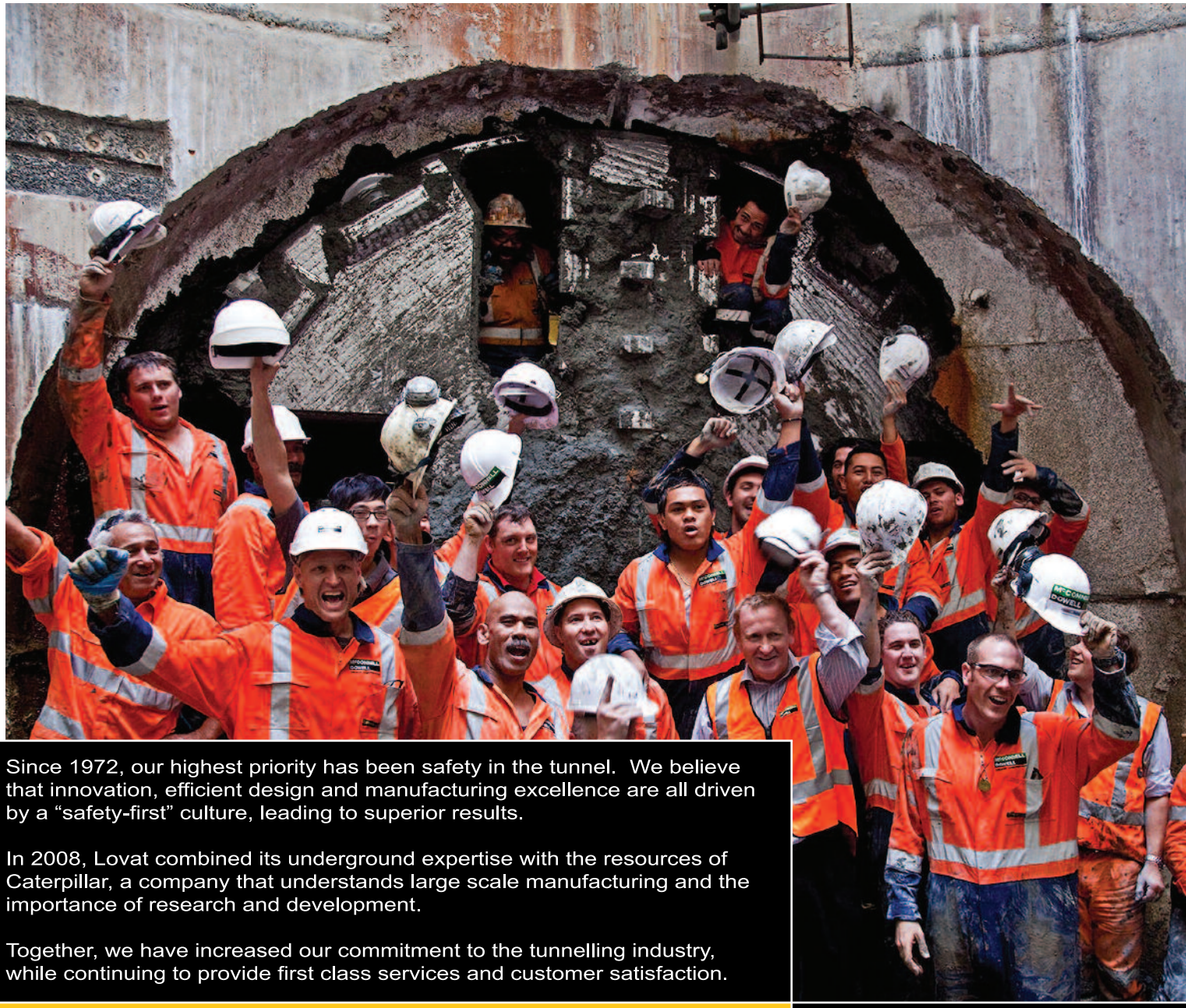
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NEXT MONTH:

Tunnelling is coming home in September with a T&TI Special Report on Britain including tunnelling in London, Brighton and elsewhere. And don't forget the Tunnels & Tunnelling International Conference in London ICE on 28 September.

The technical focus, perhaps appropriately in view of recent news, is on ground improvement for tunneling; accompanying this will be a special report on complex rail tunnel construction in Brussels.

TUNNEL WITH CONFIDENCE START TO FINISH...



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Collapse on Prague's Blanka Tunnel

CZECH REPUBLIC

A part of the Blanka Tunnel on Prague's ring road collapsed in the early hours of 6 July. The CZK 21.2bn (USD 1bn) 5.5km tunnel was under construction when the collapse occurred. The cause of the collapse, which buried an excavator driver along with his machine, is yet to be determined. A full investigation is underway.

Prague firefighters' spokeswoman Pavlina Adamcova told Czech national press that rescue workers had managed to extricate the buried man. He had no obvious injuries but remains in hospital. No other injuries were reported from the accident.

Czech national media reported that in one place the cave-in caused a 15m crater. Local residents have complained about the construction in the past, with some saying that parts of facades have fallen off. In 2008 the ground fell through in the Stromovka public park creating a 20m crater during construction.

The Blanka tunnel is to be a part of the Prague northwest ring road system. It will be over 6300m long. See in depth on page 14.



Right: The cave-in on the Blanka Tunnel caused a 15m crater

News in brief

Montana to get bike tunnel

Work to construct a bike and pedestrian tunnel in Montana will begin soon. While CMG Construction has begun work on the trail that will run up to the tunnel on either side of Main Street, Stillwater Excavating plans to start boring the 60m tunnel this month. The tunnel will have a diameter of 4.2m and is quoted at USD 1.47M

In brief

The Federal Highway Administration (FHWA) is requesting comment on a proposed new rule to establish national uniform standards for federal tunnel inspections. Currently, FHWA provides tunnel inspection guidance, but existing regulations do not require tunnel owners to inspect tunnels. Inspection methods vary significantly among the roughly estimated 350 highway tunnels in the US. Referred to as National Tunnel Inspection Standards, the proposed new standards would be modeled after National Bridge Inspection Standards.

Sofia starts drilling metro tunnel

BULGARIA

Construction has started in Bulgaria on the final section of Sofia's first metro line.

Metro Mladost Union (MMU), a PSI/Trace Sofia/Adval/Stroyinject joint venture, will build the new section. The construction will first focus on a section of 2.15km with two stations running to the Tsarigradsko Shose Boulevard.

The construction is estimated to cost BGN 223M (USD 144M).

Last month, MMU started drilling a tunnel under the Alexander Malinov Boulevard in the Mladost Quarter.

The operational section of the first subway line currently runs from the Obelya Quarter to the Mladost Quarter through the downtown. It is 18km long and has 14 stations.

From Mladost, the line is supposed to go for another 11km and 9 more stations under the Tsarigradsko Shose Boulevard to the Druzhba Quarter and then all the way to Sofia Airport. An extension will also run from Mladost 1 to Mladost 4 in the opposite direction.

The deadline for its completion is 39 months. The metro station at the Tsarigradsko Shose Boulevard will also feature an underground parking facility, the first of its kind in Sofia.

Toronto airport to get tunnel

CANADA

The Toronto Port Authority says it will be building a CAD 45M (USD 43.6M) pedestrian tunnel to the Billy Bishop Toronto City Centre Airport.

The 123m tunnel will be built 30m below the surface of Lake Ontario. Crews will start work on the island side and build towards the mainland.

The tunnel will be paid for through a public-private partnership and by applying an airport improvement fee. The current airport improvement fee is CAD 15 (USD 14.5). That is expected to rise to CAD 20 (USD 19.4.

If all goes according to plan, construction will begin in the spring of 2011 and take at least two years to complete.

Because the project doesn't involve building on or over city land, it doesn't need any approvals from the city of Toronto.

"The tunnel is going to be very functional, very easy to use, and very pleasing to use for those who haven't previously experienced using a tunnel to access an airport. I think it will anchor the airport and allow us to manage continued growth of passenger volumes," said the federal agency's president and CEO Geoffrey Wilson.

An environmental assessment is underway, with the design phase being the next step.

Passengers currently use a ferry to access the airport. The ride takes about 90 seconds. The ferries will still carry passengers after the tunnel is built and will also be used to move vehicles and supplies to and from the island.

About 1.3 million passengers are expected to use the airport this year. The authority has argued that rising passenger volumes is one reasons why the airport requires more than one point of entry.

Crossrail creates jobs for Londoners

GREAT BRITAIN

Crossrail's pledge to create lasting skills and employment for Londoners was boosted by the launch of their Skills and Employment Strategy at City Hall last week. Up to 14,000 people will be employed at the peak of construction of the railway between 2013 and 2015 giving Londoners the chance to benefit from Crossrail. The Strategy sets out how local people will be provided with opportunities to work Crossrail.

Crossrail also announced its partnership with Jobcentre Plus (JCP), which aims to provide local people with opportunities to work on the project. JCP works with a network of local job brokerage and outreach agencies to match vacancies to suitable candidates and arrange interviews.

The Mayor of London Boris Johnson said, "We want Londoners to benefit from this project in everyway and that means giving them the chance to learn the skills and benefit from the jobs created by the scheme."

"A new national tunnelling and underground construction academy and major apprentice scheme will help workers develop useful skills for future employment in the industry. Crossrail will be more than a world-class railway - for tens of thousands of people it could be the route to a successful career," added Transport Minister Theresa Villiers.

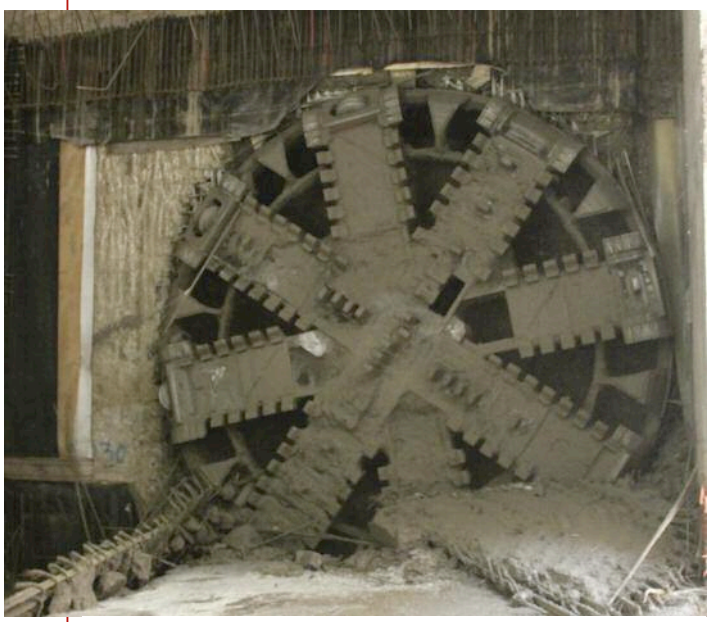
Crossrail has committed to delivering at least 400 apprenticeships over the lifetime of the project. All main works contractors will be obliged to deliver one apprentice (or equivalent) for every GBP3M (USD4.6M) spent. Apprenticeships will be offered from late 2010 as contracts are awarded. Crossrail is working in partnership with the National Apprenticeship Service (NAS) to support contractors employed on Crossrail in delivering apprenticeship programmes.

Simon Waugh, National Apprenticeship Service chief executive said, "I am delighted that Crossrail has committed to delivering at least 400 apprenticeships over its lifetime. Crossrail apprentices will not only benefit London's economy, but also have the opportunity to contribute to a lasting legacy for the Capital".

Crossrail's plan to develop a specialist Tunnelling and Underground Construction Academy (TUCA) is set out in the strategy. The volume of tunnelling and underground construction work taking place in the UK over the next decade is unprecedented but the new academy will ensure that there are sufficient numbers of people with the skills to work safely to satisfy industry demand.

Some GBP5M (USD7.7M) in funding will be provided for the Academy by the Department of Business Innovation and Skills (BIS) via the Skills Funding Agency (SFA). The new facility will ensure that all people working underground on Crossrail sites achieve the Underground Safety Passport.

Second breakthrough on Rome Metro's B1



The 6.77m diameter EPB TBM S-33 entered the station on 25 June

ITALY

The second breakthrough on Rome's Metro B1 occurred at Annibaliano Station on 25 June. Seli's 6.77m diameter EPB TBM S-33 entered the station 11 days behind schedule due to maintenance work and other set-up modifications to the tunnel conveyors.

As at April 2010, the TBM had advanced about 841m (601 rings) with an average daily advance rate of 13.6m per day.

Seli personnel are now advancing the TBM along the station. Cutterhead maintenance and repair will be performed before boring is started on the last section of tunnel between the Annibaliano and Bologna stations.

Three tunnels get go ahead

INDIA

Construction work on three key tunnel projects in India's Himachal Pradesh will start early next year. Indian public works minister Thakur Gulab Singh made the announcement last month.

Singh added that the state electricity board had prepared a pre-feasibility report and 18 consultants had shown an interest.

The tentative cost of Bhubu Jot tunnel to be constructed between Shilh Badahani-Telang on Joginderngar Ghatssani-Telang Kullu road was estimated at INR 875.5M (USD 18.7M), at that of Holi-Utrala tunnel and Bangana-Dhaneta tunnel was INR 1.4bn (30M) and INR 354M (7.5M) respectively, Singh added.

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Minister sees Hindhead progress

GREAT BRITAIN

Roads Minister Mike Penning witnessed progress on the A3 Hindhead bypass project last month when he was driven through the whole length of the new 1.9km tunnel. Penning heard that the project to build Great Britain's longest road tunnel under land and improve journey times between London and Portsmouth will reach a major milestone later this month when a 2.4km section of the approach road to the south is due to open to traffic. The tunnel itself is expected to open in 2011.

The Minister met construction workers before touring the site of the landmark GBP371M (USD 575.9M) project. Penning said, "The new Hindhead Tunnel and bypass will provide real benefits for everyone. I am impressed by the scheme's impeccable environmental credentials. The work the Highways Agency is doing here has also provided a valuable source of employment – up to 600 people have been working here at any one time."

Highways Agency project manager Paul Arnold said, "We are very pleased with the progress we are making on the project. The tunnel is now structurally complete, and in the next few weeks the new section of road at the southern end of the scheme – up to the new Hazel Grove junction – will be completely open to traffic."

The new road will remove the only section of single carriageway on the A3 between London and Portsmouth and the only set of traffic lights on the A3 outside London. The Highways Agency has been working since 2007 on the 6.4km Hindhead Bypass road project, of which the 1.9km Hindhead Tunnel is a part. Drivers should be using the first section of new road to the south of Hindhead in time for the August bank holiday.



Above: Roads Minister Mike Penning and his team after their drive through the length of the Hindhead tunnel

New sewer tunnel for Darwin

AUSTRALIA

A tunnel will be dug under Darwin's central business district in Australia for a new main sewer to be connected to the Ludmilla Wastewater Treatment plant. It is part of an AUD 80M (USD 71.7M) project to bring Darwin's sewerage system up to modern standards by replacing the notorious 'poo shooter,' that deposits over three million litres of sewage into Darwin's harbour every single day. Tunnelling will begin in September and is expected to take a year.

The contract for the AUD12M (USD10.7M) tunnelling project went to MacMahon.

The construction will use microtunnelling to minimise above-ground disturbances.

The main sewer pipe will divert sewage to the Dinah Beach trunk sewer and then on to the Ludmilla treatment plant.

The Northern Territory Government has come under fire recently after several beaches were closed due to an e.coli outbreak. The Government denied the 'poo shooter' was to blame for the outbreak. The Government plans to shut down the 'poo shooter' by October 2011 when the Ludmilla plant will be processing Darwin's sewage.

A further AUD30M (USD26.8M) will be spent extending the East Point outfall into a deep-sea pipe. The new plant will be a secondary sewerage system, inferior to the tertiary sewerage infrastructure seen in Sydney and Melbourne.

Northern Territory politician Rob Knight said it would take AUD 50M to 60M (USD 44.7M to 53.7M) more to bring Darwin's sewerage system up to the same standards as Australia's southern cities.

Breakthrough on Sochi project

RUSSIA

Russian contractor Bamtonnelstroy announced last month that its Lovat RMP167SE TBM had completed its 2848m drive and broken through at the north portal on the Sochi project. The TBM, equipped with a rock cutterhead, was the second of two Lovat machines deployed on the project and being used to build utility/escape tunnels in conjunction with the larger transport tunnels being built from Adler to Krasnaya Polyana in preparation for the 2014 winter Olympics.

The machine began at the south portal of tunnel complex no. 5. Bamtonnelstroy reported an average advance rate of 14m per day, with a record month of 400m and a record advance 25m per day. The machine encountered mudstones and sandstones with strengths of 40-60MPa.

The breakthrough came after the first Lovat machine, the 5.9m diameter RME232SE Series 14701, completed its drive at the end of May. It had started its drive at the south portal of Tunnel Complex no. 1 and broke through at the North Portal.

The total tunnel length of 2,300m (1,664 rings) was successfully completed in 311 days. The record month was set in April 2010, boring 352m (251 rings). The second highest recorded month was in its initial stages of the drive achieving 301.2m (215 rings) in October.

The completed road will be nearly 48.2km long and will serve as main access for people making their way to the 2014 Olympic games, running from Adler to the mountain resort of Alpika.

The road is scheduled for completion at the end of 2013.

Two Main Beam TBMs launched in China

CHINA

The first ever Robbins Main Beam TBMs with a redesigned ground support system replacing roof shield fingers were launched in the mountains of Gansu Province, China in June and July. The two 10.2m machines will bore the twin 16.6km West Qinling rail tunnels under high cover.

The new roof shield canopy contains mesh pockets, rather than fingers, for installation by workers under the safety of the shield structure. Other design aspects include improved ring beam building, separate roof and probe drills, and materials handling.

Ground in the tunnels consists of 30 to 80 MPa UCS sandstone and phyllite rock beneath more than 1,400m of cover. The corresponding ground support program consists of continuous mesh and rock bolts, with either ring beams or steel straps, for the length of the tunnel. Robbins vice president Brian Khalighi said, "We believe this systematic use of mesh with roof bolts and steel straps will be adequate support for the geology."

Should extremely poor ground be encountered, the mesh pockets can be relatively easily modified to use the McNally Support System, patented by C&M McNally Engineering of Toronto, for exclusive use with Robbins TBMs. The McNally System utilizes steel or wood slats to provide continuous support along the roof area of the tunnel, protecting workers from falling rock.

The two machines, for contractor China Railways 18th Bureau, were assembled at a local workshop and transported to the jobsites, where they were assembled on bridges spanning a deep valley. The first machine, for the Left Line, was launched at the end of June and has excavated over 100m after being walked through a 2km long adit tunnel. The second machine, for the Right Line, was launched on 17 July. The TBM tunnels are just 40m apart and are located approximately 1,000m above sea level, about halfway up Qinling Mountain.

The parallel rail tunnels will be used for freight, and will link the city of Longnan with the towns of Waina, Luotang and Fengxiang within Gansu Province. The West Qinling tunnels are part of the Chinese Government's Lanzhou to Chongqing Railway, a massive 820km long scheme that will link the capital of Gansu Province with southwestern Chongqing, a mega-city of over 35 million people. The new railway, at a cost of USD 11.3bn, will shorten transport times from 17.5 hours to 6.5. The entire railway is expected to open to traffic in 2014.



The machines have a redesigned ground support system replacing roof shield fingers



A Birds-eye view of the 9.75km Limerick tunnel

Taoiseach opens Limerick Tunnel

IRELAND

Limerick Tunnel, Ireland's third underwater motorway, was opened last month by Taoiseach Brian Cowen, two months ahead of schedule. The official opening will be later in the year.

The 9.75km tunnel and associated dual carriageway connects the M7 Dublin to Limerick route with the N18/M18 Galway to Limerick road and completes the southern bypass of Limerick city.

It was developed under a public private partnership between the State and Direct Route with land and construction costs amounting to EUR 605M (USD 783.4M).

About EUR 200M is to be spent on maintenance over the life of the partnership before the tunnel reverts to the State in 2041. The 35-year was signed in August 2006 and became immediately active.

The tunnel becomes the third underwater motorway after the Jack Lynch Tunnel in Cork, which goes under the Lee, and the Dublin Port Tunnel, which goes under the river Tolka and part of Dublin Bay.

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SELI

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Boring through future

Viewing restored at Box Tunnel

GREAT BRITAIN

The viewing area at Brunel's Box Tunnel western portal has been cleared of trees and foliage that prevented sight of the eastern portal. A plaque was placed at the site, five miles (8km) east of Bath, in 1988 to commemorate the tunnel's 150th anniversary, when cleaning and restoration of the tunnel also took place.

A couple of years ago, on finding the view obscured, an ex-tunnelling contractor employee Andy Hind contacted the associations who had funded the cleaning and restoration, to ask that efforts be made to restore the view from the viewing area.

After several emails and phone calls to Network Rail, this March saw the area around the portal cleared. "Now one can see this fine example of Victorian civil engineering as trains exit and enter the portal," said Hind.

Box Tunnel, nearly 3km long, was constructed between 1836 and 1841 and is named after the village of Box on the A4. The western portal is one mile (1.6km) east of Box village. At the time of opening, it was the longest railway tunnel in the world. The tunnel was built under the direction of the Great Western Railway's engineer Isambard Kingdom Brunel.



Above: Box Tunnel was constructed between 1836 and 1841 and is named after the village of Box on the A4

EFNARC certifies six nozzlemen

IRELAND-AUSTRALIA

The process of certifying experienced nozzlemen in recognition of their exemplary theoretical and practical skills has begun in earnest with the Certification of expert Nozzlemen; three from Ireland and three from Australia.

The first assessments were carried out in May 2010 at the Lisheen Mine, County Tipperary, by examiner Adam Barker. The men are employed by the mine's owner Anglo American. The Lisheen management is very proud of its men and Jonathon Talbot, Geotechnical Officer at the mine said that "Lisheen mine are delighted for the sprayers on passing the assessment and found the certification process very useful and will use the EFNARC Nozzleman certification scheme as part of the continuing improvements in shotcreting being conducted at the Lisheen Mines."

The second round of assessments was carried out in June 2010 at the Newcrest Gold Mine in Telfer, Western Australia by examiner Bo Kalin. The men are employed by Jetcrete Australia. Tony Finn, General Manager of Jetcrete Australia commented that "our current internal certification system has satisfied us for a number of years and it is of a very high standard, yes there is probably still room to improve which we constantly strive to do. In Australia there is no recognised national system and whilst we don't need the EFNARC certification scheme as such, I can see this changing sometime in the near future and if we already have our people certified by an internationally recognised body this will give us a competitive advantage."

EFNARC continues to roll out the scheme and is in communication with ITA – The International Tunnelling and Underground Space Association with a view to obtaining ITA CET and ITA WG 12 endorsement of the scheme later this year.

Sinai tunnel study completed

EGYPT

A technical study examining the possible construction of a tunnel connecting the Egyptian cities of Suez, Ismailia and Port Said to the Sinai Peninsula was completed last month, announced Egypt's investment minister Mahmoud Mohie Eddin.

The findings of the study, completed by international consulting firms, were presented at a conference in South Sinai.

The tunnel is designed to have two motor lanes and a railway track. The total cost of its construction, an estimated EGP 1bn (USD 175M), will be raised through a special fund so as to avoid any additional financial burdens on the state budget.

Victoria Park tunnel reaches critical stage

NEW ZEALAND

The construction of the Victoria Park motorway tunnel in central Auckland has reached a critical stage. As stated by the New Zealand Transport Agency, the on-ramp would be closed down for three months for the construction of supporting walls for the southern approach to the tunnel. The 440m cut and cover tunnel will run adjacent to the existing viaduct in Victoria Park, to provide three northbound lanes. The project's cost is NZD 430M (USD 316.9M).The on-ramp will be closed on 23 August and won't reopen until then end of November this year. The project will complete the final link in the central Auckland motorway network.

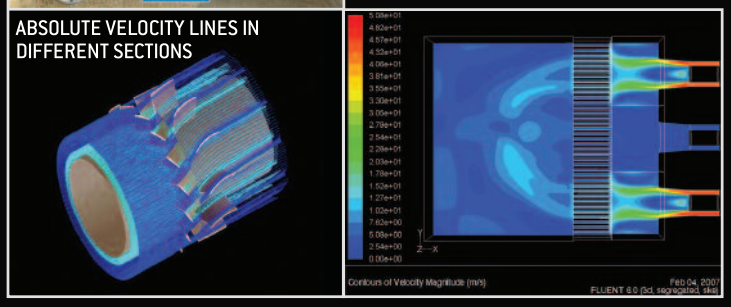
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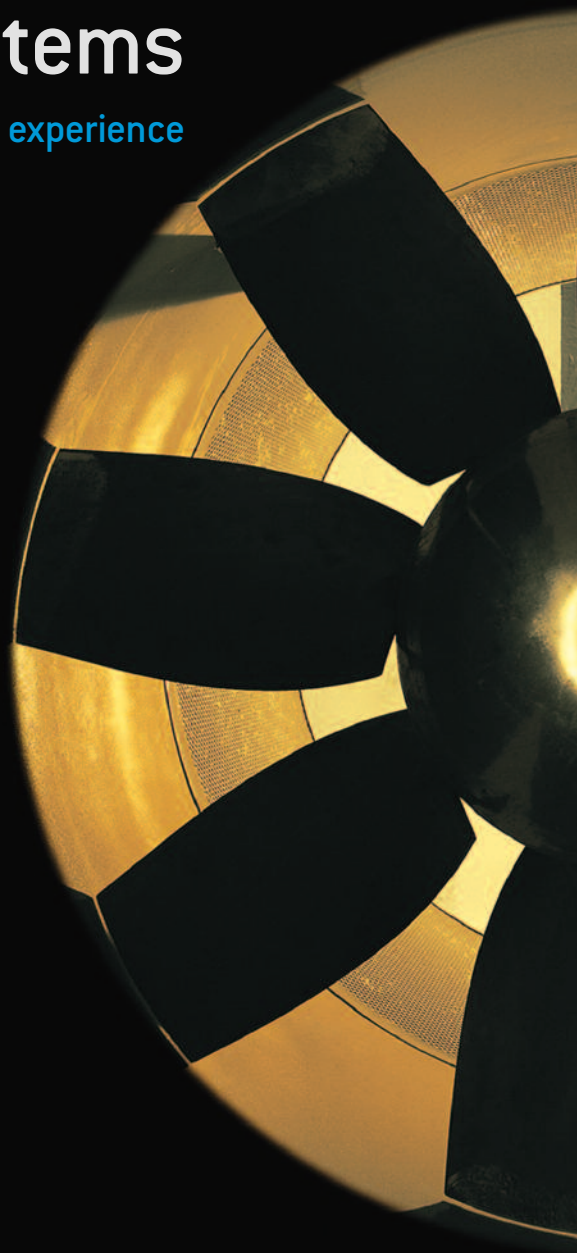
More than ventilation systems

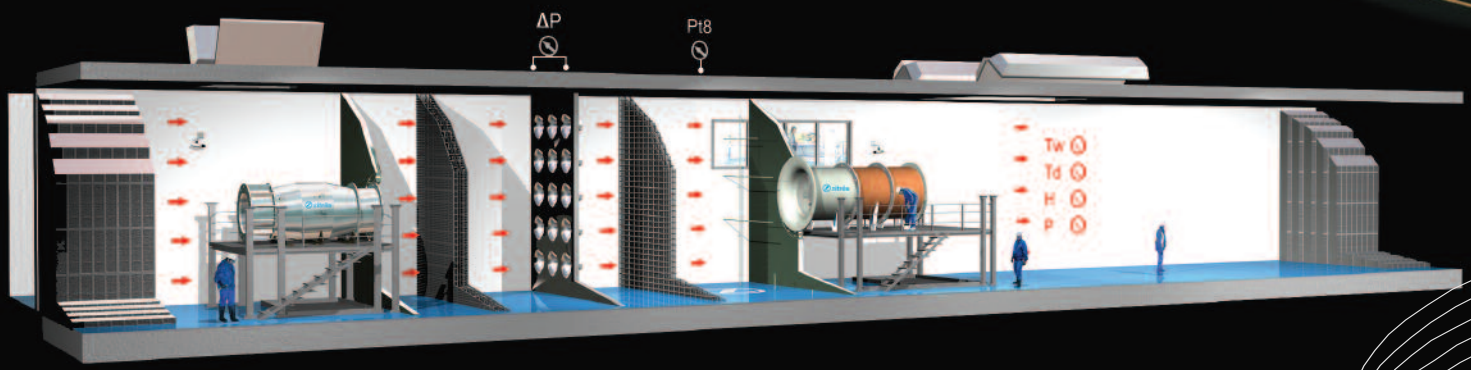
The measure of our experience



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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zitrón

More XRL contracts awarded

CONTRACT

Two more tunnelling contracts were awarded last month on Hong Kong's XRL by Mass Transit Railway Corporation (MTR).

The first contract, worth USD 177M, went to the Dragages/Bouygues jv. The contract includes construction of the Shek Yam to Mei Lai Road tunnels, which will be excavated by drill and blast. The alignment will pass through the Tolo Harbour Fault, where water ingress is expected. The second contract, worth USD 193M, went to the Maeda/China State jv. The contract includes construction by TBM of the Kam Tin Tunnels. It will include an open cut excavation as well as two 1.2km and two 800m mixed face TBM drives under villages and existing roads using one machine on turnaround.

MTR has awarded other contracts in relation to the XRL project, which include the West Kowloon Terminus Approach Tunnels North to the Bachy/Laing O'Rourke jv, and the 3km TBM driven Mei Lai Road to Hoi Ting Road Tunnels to the Dragages/Bouygues JV.

The contract for the 7.6km twin-tube drill and blast tunnels between Tse Uk Tsuen and Shek Yam went to Leighton Asia. Penta-Ocean Construction won the 2.2km TBM twin tunnel section between Mai Po and Ngau Tam Mei. CRCC/Hsin Chong/CRCC 15th Bureau JV scooped the 3.2 km dual TBM Huanggang to Mai Po tunnels contract. Contracts expected to be awarded in August include the Shek Kong Stabling Siding, and the Ngau Tam Mei to Tai Kong Po Tunnels. XRL - The Guangzhou-Shenzhen-Hong Kong Express Rail Link - comprises the underground West Kowloon Terminus (WKT), and a 26km dedicated tunnel running from WKT to the Hong Kong / Shenzhen Boundary. The entire XRL project involves 14.2 km of drill-and-blast excavation, 8.5km of mixed-ground TBM tunneling, and 2km of open-cut excavation. On completion in 2015, XRL will reduce the 20 hour journey from Hong Kong to Shanghai to just ten hours.

Mott MacDonald gets Kolkata Metro project

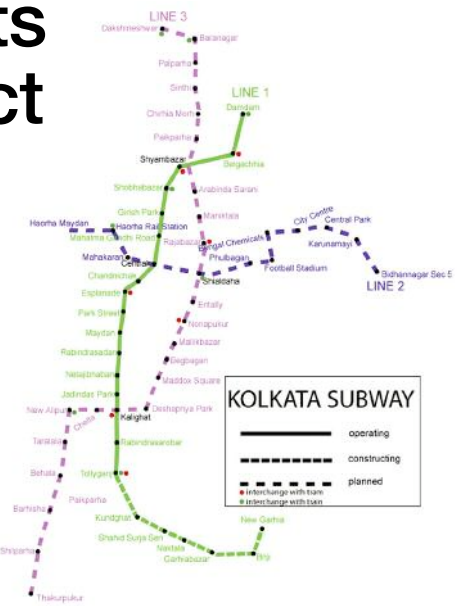
CONTRACT

The Kolkata Metro Rail Corporation (KMR) last month appointed Mott MacDonald detailed design consultant for six elevated stations on the planned East-West Corridor of Kolkata Metro. The stations are all in Salt Lake City, which currently can only be accessed by road and air, despite the town having a thriving IT sector as well as being the home to India's largest sports stadium.

The capital value of the project is INR 1400M (USD 29.9M).

"We are delighted that Kolkata Metro Rail Corporation Limited has selected us for this prestigious project. Mott MacDonald is involved in metro projects around the world including the development of Delhi Metro and it is fantastic news that we will be creating designs for landmark stations for the thriving Salt Lake City region," said Mott MacDonald's project director Gaurav Srivastava.

Srivastava added that the stations are due for completion in 2013.



Left: Mott Macdonald have been named design consultant for six stations on the East-West Corridor

Leighton Holdings gets Indian jobs

CONTRACT

Australian company Leighton Holdings has won USD 550M worth of infrastructure work in India. Analysts predict the group will report earnings of more than USD 613M for the 2010 financial year. Leighton is currently finalising an agreement to offload a 26 per cent stake in its Indian construction business to the Jindal Group. Leighton India will expand the Vizag Port on India's east coast as part of a joint venture with Indian miner Sterlite. Leighton's share in the project is worth USD 45M. Leighton will also build the Chennai-Nashri tunnel; a two-lane, 9km road tunnel in Jannu, northern India, in a government-backed project worth USD 500M. It is expected to take 54 months to complete. The tunnel is one of several government road upgrade projects in parts of the country where weather conditions can close transport links for up to 40 days. On the Vizag Port job, Leighton will add 21m to the 350m general cargo berth. Work is scheduled for completion by 2012. The company will also provide foundations for 2.5km of conveyor gallery and build a new stockyard and administration building. Both projects will start immediately. According to David Savage, chief operating operator for Leighton International, including the latest contract wins, Leighton India can expect to generate USD 2bn of revenue within five years. Turnover this year should be between USD 800M and USD 1bn.

The strategic partnership deal with Jindal will be followed by an agreement to sell a half share of two Indian toll roads worth USD 45M.

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Skanska wins Norway contract



Tonsberg, one of the stations on the Vestfold Line

CONTRACT

Skanska has been contracted to expand the railway network in Norway. The contract amount is NOK 392M (USD 61.5M), which will be included in third-quarter order bookings. The customer is the Norwegian National Rail Administration.

The contract relates to a 3.4km expansion of double track railway in Vestfold, southwest of Oslo. A 1.8km section will comprise tunneling, and about 800m associated service tunnels.

Work will commence immediately and is scheduled for completion in June 2014.

The project is part of a 12km expansion of the Vestfold Line, which will be carried out in five phases. The Vestfold Line tunnel will be the first in Norway to be designed for train speeds of up to 250 km/h.

Sound Transit recognised with award

AWARD

The National Institute of Governmental Purchasing has awarded Sound Transit its Outstanding Agency Accreditation Achievement Award for professional excellence in public purchasing policies and practices.

The three-year accreditation recognises the regional transit agency's Procurements and Contracting Division for premier best practices in eight areas of procurement and contract administration, including vision and mission, strategic planning, and transparency and integrity in contracting services. In granting OA4 designation to the agency, the NIGP commended Sound Transit for utilizing advanced technology in procurement and contracting initiatives. The award also distinguishes the agency for state-of-art purchasing practices in light rail design and construction, as well as other areas. Kunjan Dayal, Sound Transit's Director of Procurement and Contracts, said, "The award recognizes Sound Transit for conducting best-in-class public procurement processes. It also affirms our strong commitment to engaging in full and open procurement practices as we move forward in bringing Link light rail, Sounder commuter rail, and additional ST Express service to Central Puget Sound."

Cordes named founding father

AWARD

A client services manager for Black & Veatch's global water business Stephen Cordes was recently honoured as one of five founding fathers of the North America Society for Trenchless Technology (NASTT), a not-for-profit educational technical society dedicated to promoting the benefits of trenchless technology for public awareness.

NASTT serves a broad area of service sectors and works to advance trenchless technology techniques for underground pipeline infrastructure. In the late 1980s, Cordes was instrumental in bringing together the group of foresighted founders to form the organization, which was officially born as an affiliate of the International Society for Trenchless Technology in 1990.

Trenchless technology is a family of methods, materials and equipment used in the installation of new or replacement subsurface infrastructure or the rehabilitation of existing underground infrastructure. Some of the technologies include tunneling, microtunneling, horizontal directional drilling and pipe jacking, among others. The economical, green approach results in minimal disruption to everyday activities on the surface as it requires fewer continuous trenches.

Black & Veatch's history in trenchless technology pre-dates the establishment of NASTT. The company has completed numerous projects across the globe in tunneling and pipeline rehabilitation and is consistently ranked among the leading engineering companies in trenchless technology.



Stephen Cordes has been honoured as one of five founding fathers of NASTT

Pure Technologies appoints new general manager

APPOINTMENT

President and chief operating officer of Pure Technologies Jack Elliott recently announced the appointment of Tom Sangster as general manager of Pure subsidiary Jason Consultants Group, an international engineering consulting firm focused on underground infrastructure engineering and technology. In this capacity, Mr. Sangster will be responsible for the expansion and management of Jason's business in North American and international markets. He will work closely with Robert Morrison, head of Jason's North American Business Unit, in growing the business while maintaining the high standards of professional service that Jason provides to its clients.

Based in Geneva, Mr. Sangster is a chartered professional civil engineer with over 30 years' experience in civil and geotechnical engineering. His experience covers the full range of underground infrastructure engineering, and installation and rehabilitation technologies.

Questions asked as Blanka Tunnel collapses for third time

BLANKA TUNNEL COLLAPSE

Last month's collapse on Prague's under-construction Blanka Tunnel (see page 5) was the third to occur since construction began in 2007. The fall in the overburden in the tunnel tube occurred just before midnight on 4 July, 395m from the tunnel's portal. The Blanka Tunnel is to be a part of the Prague ring road system and is set to be more than 6,000m long. It is estimated the construction of the tunnel will cost about SKK 25.7bn (USD 1.2bn).

The collapse happened when temporary support walls lost stability, leading to a cave-in that left a 15m crater and buried an excavator driver along with his machine. Rescue workers, police and the fire brigade were quickly on site, and at around 6:00am were able to uncover the buried machine and pull the unconscious worker from his cab. He was taken immediately to hospital.

Control of the accident site was placed into the hands of the District Mining Authority of Kladno (DMAK), which immediately stopped all excavation works apart from work on security and future prevention of accidents. The authority also ordered that all activities be officially documented.

The cave-in was filled in up to 3m below ground level, with 2,000m^3 of concrete. DMAK will also be reviewing documents, including a geological survey, so as to minimise potential future risks when the excavation commences.

Recommendations included the gradual concreting from the surface, in order to stabilise the site, as well as implementing additional security measures, reducing tram speed limits, and employing patrols in the surrounding streets.

DMAK told *T&TI* that due to the complicated nature of the case, it could take a while to find the exact cause of the collapse. "Elimination of results of the accident, especially the earthwork, exploratory excavation, casting and overall redevelopment could, by some estimates, take more than two months," said a spokesman.

The contractor in charge of tunnel excavation, Metrostav, said in a statement that, "The investigation is proceeding under enormous pressure for fast completion, however, final conclusions cannot be drawn in such a short time due to both legislative and technical reasons. The period of two to three moths indicated by the regional mining authority is commonplace and cannot be considerably reduced."

This collapse follows in the footsteps of two previous accidents. The first happened on 20 May 2008 at Stromovka Park, as a result of extreme structural instability of the rock mass at the head of excavation caused by water intake. The quick removal of blocks of rock led to an inflow of groundwater leaching of Quaternary deposits of sand, gravel and clay. There were no injuries sustained as a result of this accident.

The second collapse occurred on the morning of 12 October 2008 due to 'unfavourable' geological conditions inside Stromovka Park. At the site of the accident, there was an unexpected structural instability of the rock mass at a fault zone. No one was injured in this accident, and no property or equipment was damaged. The collapse, however, did cause a crater 15m deep and 30m in diameter in the park.

The third collapse has led to pressure on Prague Mayor Pavel Bem to resign his post, as some local experts lay the blame solely on City Hall, saying that all three accidents were the result of poor decision making. "Prague politics has reached the bottom, and no one is ashamed anymore," said Vaclav Jandacek, an engineer and member of the preservation group Club for Ancient Prague. "People who have been in their positions for years have no moral right to remain there, but they will still muddy the waters until the municipal elections."

Josef Stulc, the main conservationist at the National Heritage Institute also raised doubts about the political decision-making, saying, "As a citizen, I can only wonder at what has been spent on the Blanka Tunnel construction, and one might wonder where the money went given the accidents at the construction site. This tunnel will not improve the Prague environment; it only conducts the main traffic into the city center. One might wonder: We have the best engineers here in the Czech Republic, so how did this happen? Either there were big savings involved, or sloppy work."

Green Party representative Ondrej Mirovsky added to the calls for the resignation of Bem, saying, "Neither of the two falls in Stromovka nor the serious inefficiency in the organization of the construction, identified by supervisors, led to new people being appointed or the punishment of those responsible. Are we waiting for someone to die in another accident?"

Bem, meanwhile, says the safety of Prague residents remains a primary goal. "Our highest priority is the absolute safety of city residents," he said. "We do not want only information, but also a guarantee, and then we will be ready to continue this costly construction, which is unique in Europe and is being paid entirely from the budget of the city of Prague." He added, "It is definitely not going to cost more, but all the costs associated with the tunnel collapse will be fully paid by the supplier, including the safety and remedy works."

Kris Mole



Above: **Prague Mayor Pavel Bem**





One for two.

Herrengrosserstedt/Germany. As specialist in conveyor belt systems, H+E Logistik GmbH supplied the equipment required for the new construction of 2 tunnel tubes with a length of 7,000m each, which will accommodate a high speed train on the German railway route from Erfurt to Leipzig/Halle. This equipment guaranteed rapid tunnelling progress. The system includes two continuously extendable tunnel belts which are connected to a heap belt and operate a pivoting stacking system. This saves costs and maintenance work. Typical H+E.

The bare facts:

Tunnel diameter:	10.90m
Conveyor length:	2x 7,000m
Belt width:	1,000mm
Capacity:	2x 1,400 t/h
Installed power:	3x 250kW per tunnel
Belt storage capacity:	2x 500m/horizontal
TBM:	2x Hard Rock Shield
Installation:	2008
Contractor:	JV Finnetunnel



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www.helogistik.de

We've been schooled

Dear Sir,

As a subscriber to T&T international I read your article "A guide to education" (T&TI, June, p32). Many certified M.Sc. or training courses may be encountered there, which are provided by pertinent Universities, Societies, or Institutions. However, the endorsed course we have been running for more than 10 years was missing there.

Since 1998 a PG Course entitled "Design and Construction of Underground Works" has run annually at the National Technical University of Athens. It is an endorsed ITA course, co-organized by the Schools of Mining and Civil Engineering, which leads to a postgraduate degree. The course language is Greek and is open to graduates with a degree in engineering or geology.

Applications for the program are in June, and it will run next academic year from autumn 2010. Most of the curriculum will be the same as previous years. The course is subdivided into three semesters. For the first two the students attend lessons and classroom exercises, and also visit worksites all over the country and abroad, for which they have to provide reports on their assignments. During the third semester they work on their thesis.

Special lectures are provided by experts both from the academia and the profession. The presentation of a thesis concludes the obligations for the course.

A pool of companies provide some financial help for the site visits. The course completes within one academic year. However, there is an option for professionals to extend their duration in the course for a maximum of two years.

Prof. Al Sofianos
National Technical University of Athens

What's in a name?

Dear Sir,

I've never really got the need to name tunnel boring machines. It is most amusing to see that the machine for Brighton is called 'Athena' (T&TI, July, p5).

Lets hope that its fate is not the same as its namesake;

the ship named 'Athena B' was washed-up on Brighton beach in 1980.

Darren Page
OTB Engineering

Silane gets second opinion

Dear Sir,

Silanes protection against salts is a fairy story (T&TI May 2010 p47).

I note from the article there is no claim to longevity of the material. Many years ago the late Professor Joe Cabrera of Leeds University Civil Engineering Materials Unit (CEMU) prepared a paper on silanes and proved that they had an effective life in certain conditions of only 18 months.

In the UK the Highways Agency (HA) were spraying everything (especially bridges) with silanes, but Cabrera managed to get the paper published in France as I was informed he was not able to do so in the UK.



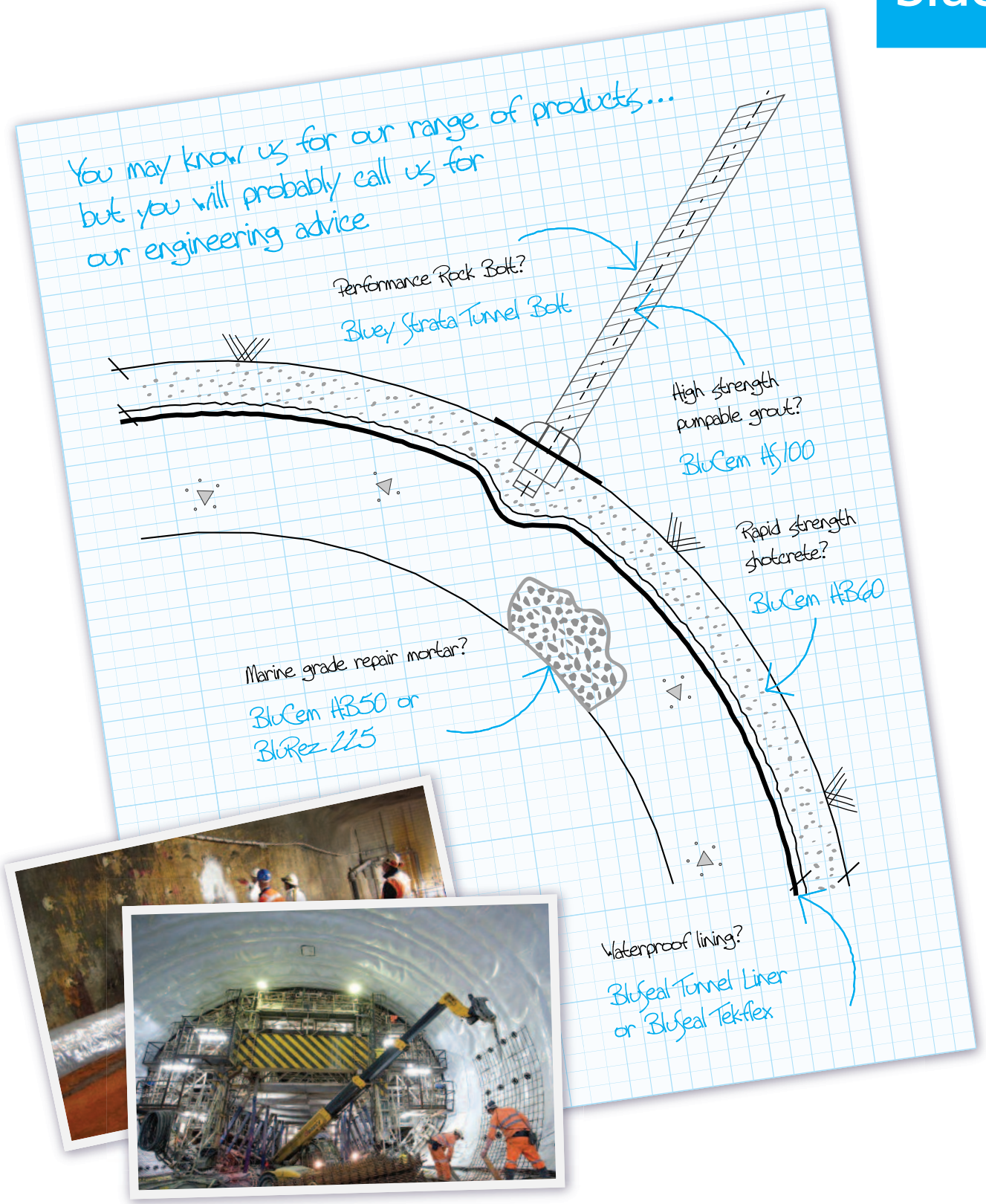
In the past the company that I worked for carried out work with the silane materials, some of which were at one point banned in the UK, due to some manufacturers' products having suspected carcinogen fears for the applicator.

Silanes were found to have limited depth of penetration, did not fill cracks and when exposed to harsh environments the surface of the concrete wore away removing the protection. Therefore they are not the answer to water penetration into concrete.

I have had tests done at Leeds CEMU that proved that the non-silane material. I was using was far superior to any silane in the protection against water penetration and protection of reinforcement. However unless but the HA were given 30 years proof they would not accept the product.

Phil Richardson
Natural Cement Distribution Ltd.

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North America's project potential

Juggling the increasing tunnel work with a decreasing amount of manpower, North America is finding a balance to get the job done, reports Nicole Robinson

North America's well-worn reputation as the land of opportunity has never been truer—for the tunnelling industry at least. With work from coast to coast in both Canada and the United States, the biggest problem facing this market is a lack of skilled workers at all levels. Despite the shortage, and to not mention rough economic circumstances, major projects for transport, metros, water and power are moving forward and opportunities are abundant.

One of the most interesting projects in North America at the moment is the Alaskan Way Viaduct in Seattle. Local authorities have recommended replacing the viaduct's central section with a bored tunnel. The project will require building one of the largest soft ground TBMs in the world to create the 2.77km long Washington State SR99 bored tunnel. It will accommodate two lanes each 3.66m wide, among other features of the 15.8m total diameter. The Washington State Department of Transportation released a request in May to pre-qualified teams for the SR 99 bored tunnel alternative design-build project. The cost for the tunnel is estimated at USD 1.96bn, with major construction expected to start next year and the tunnel to open to traffic in 2015.

In June, another traffic project marked a significant moment in its progress. The Miami Access Tunnel (MAT) held a groundbreaking for the USD 1bn tunnel connecting Watson Island to the Port of Miami. Headway on this project follows various stalls since its inception in 2006 due to financing, but officials are hoping for a 2014 opening. The consortium, led by Bouygues, will be using a USD 45M Herrenknecht TBM to create twin tubes, each containing two traffic lanes. The tubes are each approximately 1.1km long, 12.5m in diameter and will be up to 120 feet below the water. Herrenknecht will build the TBM in Germany and ship parts to Miami to be assembled. Construction is expected as early as summer 2011.



Above: **The Port of Miami will start tunnelling as early as summer 2011**

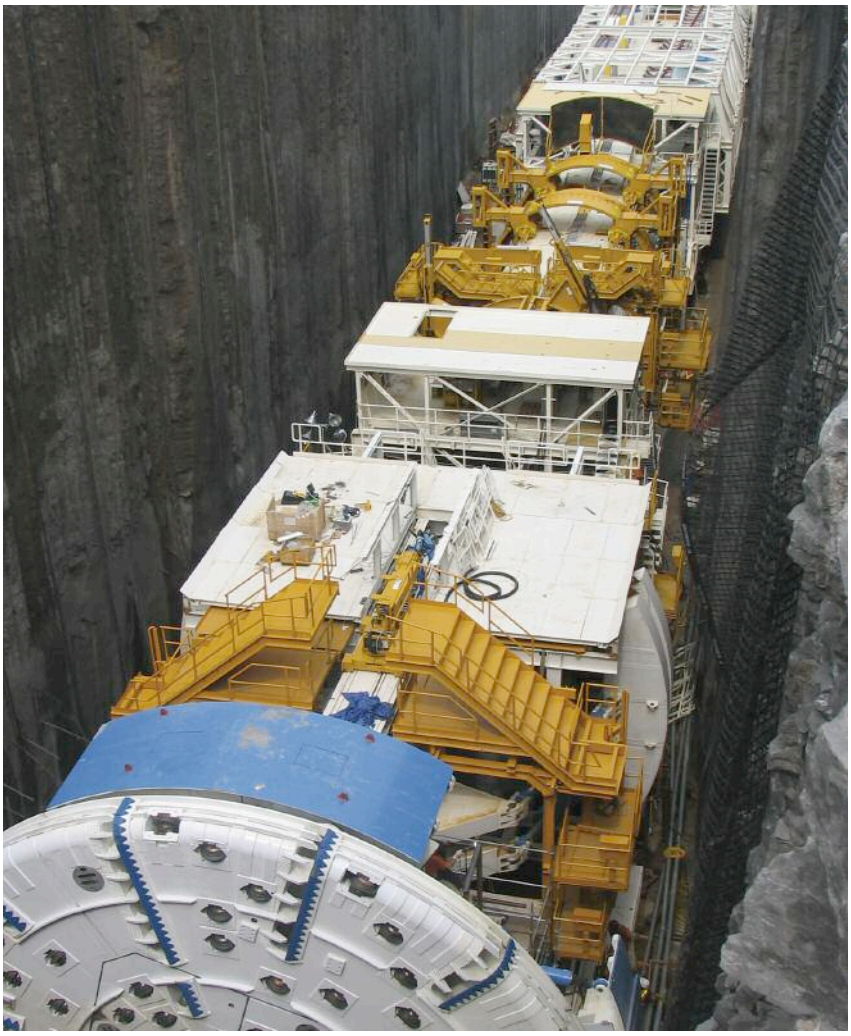
Dennis Doherty, senior trenchless technology engineer at Haley & Aldrich, says across the US there is a lot of CSO, water and waste water projects happening across the country, which in turn means there are a lot of those types of tunnels going on too.

A more notable project, the Ontario Power Generation's (OPG) 10.2km long Niagara Tunnel will route water from the Niagara River and carry it downstream to the Sir Adam Beck Generating Stations. OPG says with this tunnel it can provide enough clean water power to generate a further 1.6 billion kilowatt-hours of electricity annually, enough to meet the electricity needs of about 160,000 homes. Contractor Strabag A G of Austria is using one of the largest hard rock TBMs, in the world to drill the 14.4m wide tunnel.

Despite a stall between September and early December 2009 due to a 25m section of the ceiling partially caving in, the TBM has now passed the 7km mark after being taken out of service in May for a planned overhaul and will resume boring in late June. This summer has also seen a start to concrete work on the final stage of the 600mm permanent tunnel lining, which will continue until autumn 2012.

Water and wastewater is a strong market, Doherty says, primarily because of EPA rulings. "There are highway tunnels, transit tunnels, and so forth, but I think with the EPA pushing consent decrees out there and a lot of the combined sewer overflows—often they're just installing deep block tunnels or deep tunnels for storage—just to meet that demand alone is eating into the resources."





Right: **'Big Becky' has passed the 7km mark of the Niagra Tunnel**

Executive chair of the World Tunnelling Congress Rick Lovat agrees there is plenty of demand to go around. "The major challenge we have here is developing the resources going forward for the work that is coming," he says.

In the near term, there's going to be a lot of work in Toronto particularly, he explains, saying in the coming months Toronto will be a "hot spot" for subway work, metro work and for some water transfer work and sewage work. The Toronto Transit Commission (TTC) has created the Transit City initiative to develop Light Rail Transit (LRT) lines in neighbourhoods not currently served by rapid public transport. Currently, it is working on four projects including the Eglinton Crosstown LRT, which would run underground for a 12km section. The majority of the underground segments will consist of twin tunnels, each 6m in diameter using TBMs. Stations, portals and areas for track work will be constructed by cut-and-cover. Separate from the Transit City programme, TTC expects construction to start this year on 8.6km twin tunnels for the Toronto-York Spadina subway extension, using both a TBM and cut-and-cover. This spring, contracts were awarded to Varcon Construction for the TBM launch shafts at Sheppard West Station and to HC Matcon Inc. at Steeles West Station. Toronto-based Lovat Inc. has been awarded a CAN 58M (USD 56M) contract to build the four TBMs that will be used to build about 6.6km of the tunnel. The TTC expects the project to tender the six major facility contracts between now and January, with two by summer's end—the Sheppard West Station and South Tunnels contract by end of July and Highway 407 Station and North Tunnels contract by end of August.Elsewhere in Canada, Ottawa is looking at tunnelling for upcoming transit work, and Vancouver's new Evergreen Line will include a 2km bored tunnel with depths between 17m and 60m. The Evergreen project submitted its Application for Environmental Assessment Certificate Application in May, and is currently in the public comment period until August 29.

The tunnelling industry in Canada, looking at both the medium and long term, is quite healthy, Lovat says. "Today there is plenty of work, and the farther you look out there's plenty of work." Though challenges due exist, he says, "Canada is still regional in a sense that contractors don't tend to move across the country very well." Lovat thinks this is a result of being under-resourced—contractors take care of their own backyard and then when something else comes up the next province over they become too strained to move. "Which then opens the doors for two things to happen, people from south of the border come up or from abroad, from Europe," he explains. "And from a Canadian perspective we haven't seen much cross border activity. We see it from the consultants. There's no doubt the consultants are travelling north-south, but we don't see many American contractors coming up into Canada to fill those voids that exist. Which is somewhat surprising, but that then tells you that they themselves are quite occupied back at their home base, which is very much the case."

New York City is seeing multiple commuter rail projects, including New Jersey Transit's Access to the Region's Core, also known as the Mass Transit Tunnel. This project will connect New Jersey to Manhattan via single-track tunnels under the Hudson River. The contract for the 2.26km Hudson Tunnels has not yet been awarded, though five contractors have been pre-qualified to proceed to Phase II for the final design and construction. Two other contracts for tunnels on the New Jersey and Manhattan lengths have been awarded. A USD 583M contract went to Barnard-Judlau jv for the 1.6km long Manhattan Tunnels, which will connect to a new underground expansion of New York's Penn Station. The two 1.6km TBM bored Palisades Tunnels will run through the Palisades hard rock on the New Jersey side of the river. Meanwhile, New York's Metropolitan Transport Authority (MTA) is excavating rail tunnels for the East Side Access project. Crossing under the East River, the tunnels will connect the Long Island Rail Road's Main and Port Washington lines in Queens to a new terminal beneath Grand Central Station in Manhattan.

"The choke point right now is to be able to get the work done," says Doherty.



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Jon Young
Editor, Tunnels and Tunnnelling

Watch this space for further announcements but make **September 28th** a date at the ICE

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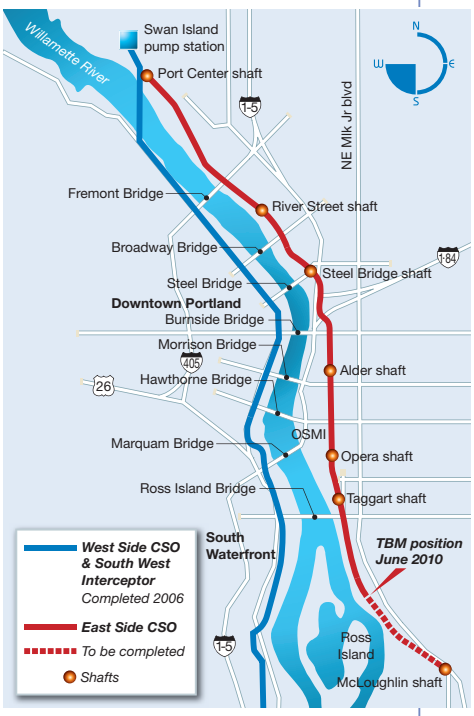
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Home run for river clean up

Portland, Oregon has had more than its fair share of tunnelling work in recent years, all geared to improving the quality of its waterways particularly the Willamette River. A key and largest stage in this programme has been the East Side Combined Sewer Overflow Tunnel Project, which is now approaching its conclusion after passing several milestones in the development of North American tunnelling. Maurice Jones reports.



Above: **The main East Side CSO project tunnel over the Willamette River to the completed West Side CSO project joining at Swan Island**

A joint venture of contractors Kiewit Corporation of Nebraska and Bilfinger Berger of Germany (KBB) is working to complete the last drive of the sometimes arduous East Side Combined Sewer Overflow (ESCSO) project for the City of Portland Bureau of Environmental Services.

Overall programme

Once operational the new sewer will allow the full interception of most combined sewer overflows before reaching the Willamette River, and so improve the quality of the water flowing through the City to join the Columbia River and the Pacific Ocean.

The East Side CSO Project is the largest construction project in Portland's 20-year program to control or eliminate combined sewer overflows (CSOs). The programme combines major projects like ESCSO with more community schemes. CSO incidents have, in the past, occurred every time it rains, but once the overall scheme is complete it is reckoned that incidents will be limited to only two or three each year.

Utilising a series of nine microtunnelled drives totalling 2400m in length and all completed last year, the flows of existing outfalls will be diverted into special structures within new shafts along the east bank of the river and thence into the 6.7m-diameter main tunnel. This will carry the combined sewage and stormwater to the Swan Island CSO Pumping Station to the north of the combined sewer area of the city, and subsequent treatment, instead of being dumped in the river. One of the project's many major achievements has been North America's longest mechanised pipe-jack drive at 931m (3055 ft). This was achieved with a Herrenknecht AVN D2000 slurry machine with a cutting diameter of 104.5 in (2.654m), which allowed for an 84in. (2.134m) diameter pipe to be installed.

In addition 4,000ft (1,200m) of diversion sewers to the main shafts were laid by cut-and-fill. All collector sewer pipes range in diameter from 18 to 84in. (457-2134mm).

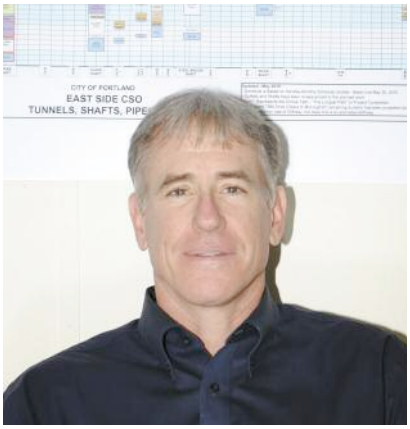
Main drives

Mirroring, but substantially longer and of larger diameter than the West Side CSO project, completed in 2006 by a joint venture of S A Healy and Impregilo (Italy), the main tunnel drive route of the ESCSO will run from the McLoughlin Shaft in the South to the Swan Island Pump Station in the North where it will merge with the West Side CSO project flow at the Confluent Shaft, built as part of the West Side project.

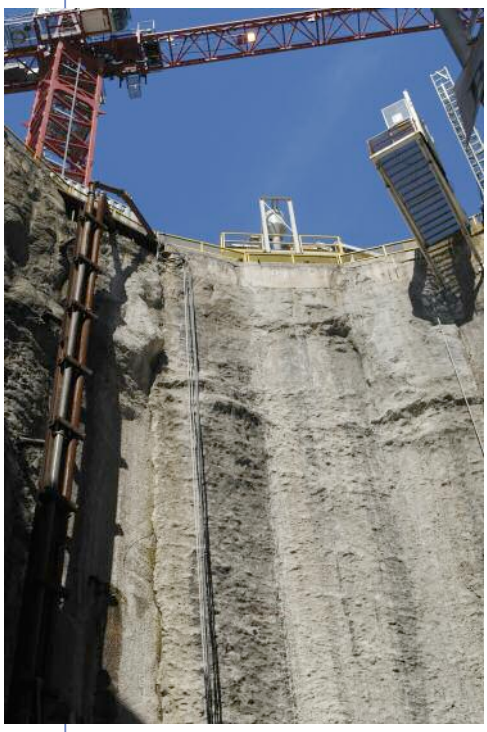
Kiewit combined the internal expertise of three of its own divisions or districts with the slurry-shield and microtunnelling experience of Bilfinger Berger to create a team capable of tackling the sometimes tough ground conditions as well as the size of the project, valued at USD 433M.

The project is led by Kiewit director Tom Corry and field operations by project manager Niels Kofoed, who joined Kiewit after working with them on Storebelt.

The main sewer runs for a total length of 8.9km, linking seven shafts and, with the microtunnels, intercepting combined sewer overflows that have been polluting the Willamette River. The main tunnel depth



Right: **Project director of KBB, Tom Corry**



Above: **Looking up the Opera Shaft showing lining structure**

ranges from 25 to 50m in a very mixed geology. The Troutdale Formation, comprising 85 per cent of the tunnel horizon, is understood to be a fluvioglacial deposit but, explains Niels Kofoed, indicative of catastrophic flooding, such as might be caused by the breaching of a natural dam, which caused everything from sand to boulders to be deposited along the valley haphazardly. The material is therefore very unpredictable as well as abrasive.

Shafts

Construction of the seven main shafts (several smaller and shallower ones were required for microtunnelling) was no simple matter either, due mainly to the mixed and sometimes hard ground but particularly due to the high water table next to the river. The basic construction consisted of slurry wall support with subsequent cementation, and tremie construction of concrete poured under water in the flooded shaft to ensure no collapse of the shaft due to groundwater pressure at depth. Once the slurry walls had been installed, excavation could be carried out within the shaft area. This was possible in the dry down to 15m. Then the shaft was allowed to flood to hold back groundwater pressure, and excavated to the required depth, using clamshell excavators in both dry and wet.

At construction depth a rebar reinforcement mat was lowered through the water to the bottom of the shaft. Divers pinned the reinforcement mat to the side of the excavation using dowels, after which the concrete could be tremied over the mat to create a reinforced slab that was designed to hold back the groundwater pressure and prevent a blow-out.

TBM choice

Although only the second time that a large diameter pressurised slurry TBM had been employed in North America, the Herrenknecht Mixshield TBM design was chosen on the basis of its ability to control groundwater pressure at the face under variable permeable ground conditions. The groundwater at tunnel horizon is normally 2.8-3.2bar pressure, with 3.5bar maximum.

The cutterhead had to be able to withstand the abrasive and sometimes hard, blocky ground although, due to the nature of the formation, no one could be certain of how much of each type of material could be expected.

TBM control is aided by the use of a VMT guidance systems that also, tunnel party chief Burnel Preston explains that the guidance system was subject to regular survey checks by his team, it greatly reduced the amount of surveying required.

The tunnel drive from Opera Shaft to the north took from June 2007 to October 2009. It is chiefly in sand and gravel, but the northern end of the drive encountered large boulders that slowed progress both during tunnelling and overall. However the arrival of the TBM at Port Center Shaft matched what was originally scheduled some four years earlier. Face cutters became worn and damaged towards the end of the last drive neccesitating major refurbishment.

Even thought tougher cutter shoes and other measures had been installed during the break (see below), the TBM was deliberately controlled so as not to cause major problems such as broken cutters or slurry blockages. TBM operator, Tracy Cordova, explains, “we normally operate at up to 1400kNm torque, slowing down at 2000kNm to avoid spoil removal blockages. The normal cutting speed is 1.5-1.7 rev/min using eight motors on the cutterhead drive gear. The shield thrust is carefully controlled to avoid any more cutter damage in boulder ground. Overcut up to 17.5mm is possible, chiefly to negotiate curves. We guide the shield with the thrust rams according to monitoring from the VMT laser guidance.”



Left: **Tracy Cordova (right) training up a TBM opeator in ‘Rosie’s’ control cabin, showing VMT guidance display at top**

A crusher also assists blockage prevention over a grizzly in the return line of the pumped slurry system within the shield. This can apply a force of 300bar to reduce boulders to a small enough size to pass through the grizzly for pumping.

All tunnelling and microtunnelling was subject to instrumentation for ground movement or changes in groundwater elevations, with more detaled checks of mre sensitive and high risk structures near the TBM. Corry explains, “for some of the riskier structures (e.g. bridges), we were required to tunnel 24/7 and monitor every four hours. The ground/water devices included inclinomaters, piezometers, deep and shallow surface settlement markers and utility monitoring points. Besides this we monitored many of the building with a ‘Cyclopes’ (a total station and prisms set up to continuously monitor the building) for movement and cracks.”

Lining & spoil

Although both the East Side and West Side tunnels have become known as the ‘Big Pipe’ locally by the client and community, they are actually constructed of one-pass pre-cast bolted concrete segments, 5ft (1.52m) wide and 14in. (356mm), made in a plant operated by Kiewit on the west bank opposite the Opera Shaft. Each lining ring, of two types, has eight segments with 15 per cent of the reinforcement provided by the usual rebar cage, and the rest by steel fibre. All segments, fitted with Phoenix joint seal gaskets, have now been made with the remainder stacked awaiting installation.

Curves or correction of deviation in the tunnel construction are, as usual, made by the position of the lining ring. The VMT TBM control system records all ring builds and has all possible ring positions programmed into the system so they can be called up according the line correction, if any, required. Each is designated according to the key segment position chosen from 14 possibilities.

As it is a pressurised slurry shield TBM system, the spoil is pumped direct from the cutterhead, via the crusher, to the surface, using intermediate pumps to keep up





Right: **KBB general superintendent of tunnelling, Helmet Schulmeyer (left) and project manager Niels Kofoed at the Opera Shaft**

delivery as necessary. After settlement and removal of fines in a purpose-made treatment plant, fluid is returned to the slurry circuit whilst removed solids are bunkered or carried by cantilever-structure belt conveyor to barges on the river. From there the spoil is carried 1.5 miles (2.4km) up river to Ross Island where it could be used to reclaim a lagoon located a lagoon.

Personality

At its launch, the TBM was named 'Rosie'; as part of a community spirit and support programme typical of city-managed construction projects in North America. While naming a TBM is no longer unusual worldwide, to have a TBM transmitting messages on the microblogging site Twitter was probably a first.

When Rosie reached the Port Center Way Shaft on Swan Island on 30 October last year, after boring 4 miles (6.4km) from the Opera Shaft, it 'said', "I've been building this big pipe for more than two years now. It'll be nice to come up for some fresh air next month and take a break."

Rather than taking a 'break', 'Rosie' was destined for a trip up the river to the Opera Shaft site and a major facelift.

Big move

At 417tonne (460 ton), Rosie is quite a weighty lady, and needed a 700t crane to lift the main section form the 100ft (30.5m) deep shaft, followed by the 63.5-tonne (70-ton) tail shield, all under the careful supervision of specialist heavy-lift movers Emmert International. The sections were laid on self-propelled hydraulic drive platforms to carry them to barges on the Willamette River to be towed up the river to a position on the east bank adjacent to Opera Shaft. Here Emmert had prepared the ground and laid a steel ramp at a suitable grade so that the TBM could be transported up the bank to a position on the construction site for refurbishment.



Left: **A special ramp was laid to ease 'Rosie's' passage up the river bank to the Opera Shaft site [Photo: KBB]**

"Emmert put a good plan together and performed the move of our TBM proferssionally and without any mishaps," say Corry and Kofoed.

Major refurbishment, chiefly to the cutterhead, was necessary after the four miles of tunnelling, even though backloading cutter change interventions were carried out before entering each shaft in order to maintain gauge cutting before boring through the concrete of the shaft. The major refurbishment was carried out by the joint venture on site. Tunnelling superintendent Helmut Schulmeyer, who was in charge of the refurbishment, explained that the abrasive ground had worn many of the cutter shoes virtually flat. It was also found that worn out shoe seating, causing cutters to wobble under loading, had led to the loss of many cutters on the first drive, especially when big boulders had been encountered.

"The last 2,000ft (210m) were in the worst ground conditions and very difficult," comments Kofoed, "but, considering the ground, we've been very pleased with the machine."

The refurbishment work included grinding out the old shoes of each cutter to allow welding in of new seatings. Also 5000lb (2,268kg) of hard facing was applied to the cutterhead for better general durability.

The rate of tunnelling has been greatly dependent on the type of ground material, but was helped initially by the experienced crews that could be recruited from the West Side CSO Project (see T&T North America March 2008 and June 2004) as well as the even more experienced site management of Kiewit Construction and Bilfinger Berger. The rate of tunnelling on the first drive was an average of 73m a week, 20 per cent better than schduled. On the south drive, where the most favourable ground conditions are present, 'Rosie' is chewing up the ground at almost double the scheduled rate.

The final breakthrough to the McLoughlin Shaft is scheduled for later this year. As at the last report before going to Press, 1,419m had been completed leaving 1266m to reach McLoughlin. At the current rate of progress the south drive is expected to hole through in October and the deadline for substantial completion of construction by 15 September 2011 should be met slightly early.

Meanwhile the Opera Shaft site has to be vacated quickly as other infrastructure projects are waiting to claim the space on the banks of the Willamette River including a streetcar route extension and TriMet's Light Rail Extension Project.

Installation on the rest of the scheme is already under way, but once all valves, controls and monitoring devices have been fitted and commissioned, the client will activate the East Side 'Big Pipe' towards the end of 2011.

PROJECT DATA

Client/Owner: City of Portland Bureau of Environmental Services

Main engineering design: Owner and Parsons Brinckerhoff

Main contractor: Joint venture of Kiewit Construction (three districts) and Bilfinger Berger

Current contract value: USD 433M

Tunnel dimensions: 8.9km long, 22ft (6.706m) i.d., 24ft 4in (7.417m) o.d.

Main shafts: Seven in diameters of 15.2-21.3m

Shaft design: Parsons Brinckerhoff

Main TBM: Herrenknecht slurry-shield machine named 'Rosie', 7.72m diameter

Microtunnelling: Herrenknecht AVN D2000 for a total of 2400m of collection sewers feeding shafts including one drive of 931m

Scheduled activation: Q4 2011

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So San Francisco doesn't go thirsty

Like most infrastructure in the San Francisco area, the Crystal Springs By-pass Pipeline can be affected by seismic activity, so the risk assessment of its design, safety and functionality has to take this into consideration. It was decided that the risk, from landslide damage to the pipeline in particular, was too high to rely on the original structure, so an alternative by-pass tunnel was decided upon as just one, but a vital, part of the Water Supply Improvement Progam (WSIP) undertaken by the San Francisco Public Utilities Commission (SFPUC). Maurice Jones reports on its completion.

The New Crystal Springs Bypass Pipeline is nearing its end with all excavation complete and its water-carrying steel pipe being grouted into position within the tunnel structure using cellular concrete. As if to emphasise the purpose of the project the area experienced a significant tremor (4.1 magnitude) just before a planned community site visit. The project's groundbreaking ceremony took place two days before the 103rd anniversary of the 1906 Great San Francisco Earthquake and Fire, which cut off local water supplies. The New Crystal Springs Bypass Tunnel water supply route provides a critical link to help ensure water to San Francisco and San Mateo counties after a major earthquake.

In addition to its critical place in the WSIP (see below) with seismic upgrading, there was additional motivation for the move to replace the existing Crystal Springs Bypass Pipeline. A major landslide occurred during the winter of 1996-97 on the northeast side of the Polhemus road, threatening the structural integrity of the existing prestressed concrete, steel-lined pipeline lying 7-10ft (2-3m) below the surface of the hillside bordering the road. This raised concerns about future landslides, whether from seismic activity or extreme wet weather, affecting system reliability. As a result of subsequent studies into the replacement or repair alternatives, a deep tunnel was chosen as the preferred option. The scheme was designed by a joint venture of Arup and Brierley Associates, and Jacobs Associates were appointed as construction manager.

Dimensions

The new tunnel is 1280m (4200ft) long and 2.44m (96in.) finished diameter with a welded steel liner, and is due for completion in spring next year. At the time of T&TI's visit tunnel excavation had been completed and the steel liner was being fixed in position within the tunnel with cellular concrete annular backfill.

The tunnel construction contract was awarded to the lowest qualified and responsible bidder, the M L Shank Co/Balfour Beatty joint venture, in October 2008 at an amount of USD55.674M.

The tunnel work is located along the Polhemus Road in San Mateo County, with most of the construction site occupying the location of decommissioned Polhemus Fluoridation Station. The site, which is surrounded by residential and equestrian plots, will be fully restored to a natural state at the completion of construction, including modification of surface drainage.

In addition to the tunnel, excavation work included:

- two shafts, of 9.765m (32ft) diameter at the south end for most working, and of (18-ft) diameter at the north end of the drive;
- the construction of valve vaults;
- control and monitoring systems and;
- a 20-kW emergency power system.

In addition the contractor installed inclinometers along the slope bordering the Polhemus Road and on each shaft site to monitor stability.

On completion of the new pipeline it has



Above: **Victor Romero does a site inspection as sheet piling of the valve and manifold chamber continues in background**



to be connected to the existing Crystal Springs Bypass Pipeline and Tunnel, other supply pipelines in the vicinity and back to the Crystal Springs Reservoir. This is being accomplished in a shallower excavation on the construction site with sheet-piled walls to accommodate valves and connections.

The existing Crystal Springs Bypass Pipeline will remain in partial service to provide redundancy for inspection and maintenance of the new tunnel.

Geology

Jacobs Associates Principal responsible for the project, Victor Romero, explained that the contractor itself was allowed to select the depth of the tunnel (within limits). This allowed work to take place in the best ground horizon found, as long as pipeline water flow could be maintained with a gradient of 0.2-3.0 per cent. The ground is in the Franciscan Formation or Assemblage, which is of very mixed (heterogeneous) material affected by numerous seismic disturbances and bordering the San Andreas Fault in the San Francisco Peninsula. Typical materials include volcanic greenstones, deep-sea cherts, greywacke, limestones, serpentinites, shales and metamorphic rocks formed by high pressure through tectonic movements. Although the design documents include the Geotechnical Baseline Report, Romero commented, "We just couldn't 'join up the dots' in the section from site investigation. So the contractor had to expect a range of ground."

The contractor selection of the horizon could be based on the best horizon found during shaft construction, of relatively 'good' sandstone for launch of the TBM, resulting in a constructed grade of 1.2 per cent from a launch shaft depth of 50.3m (165ft) to meet the designed reception shaft depth of 18.3m (60ft).

M L Shank, led by veteran Mike Shank, is a small but well-known tunnelling specialist in North America with a wealth of experience. It is known particularly for concentrating on one project at a time, the previous one being the Narragansett CSO in Providence, Rhode Island, and for designing its own TBMs for custom build, usually by Hitachi Zosen of Osaka, Japan.

For Crystal Springs Mike Shank had the Hitachi Zosen single-shield tapered from the 3.71m (146in.) at the cutterhead down to 3.63m (143in.) at the rear of the shield in case of squeezing ground. Shank specified 17in. (432mm) hard-rock cutter discs from Herrenknecht and a Rotek main bearing.

The back-up system included an erector for expansion pre-cast lining segments, a railed gantry, and a belt conveyor.



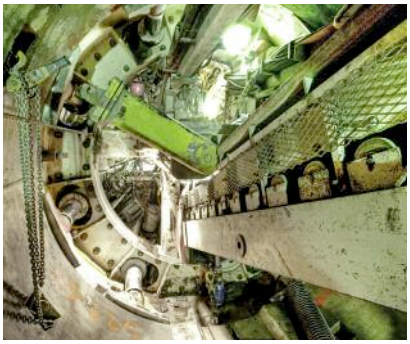
Above: **Complicated welding required for a pipeline tee-joint at the base of the North Shaft. In the background is a covered butterfly valve [Photo: Jacobs Associates]**

Shafts

Before tunnelling could begin both shafts had to be sunk, using drilling and controlled blasting during daytime hours only throughout the first half of 2009. A special shaft-drill jumbo was employed to get through the hard ground. Blasting had to meet noise and vibration limits in view of the proximity of dwellings.

Initial support of the shafts in the superficial ground material was by soldier piles and steel rings with timber lagging. At bedrock one cast in situ concrete ring holds the upper structure, after which the remaining depth of shaft in more solid rock was supported by sprayed concrete over steel rings.

In July the TBM shield arrived on site from Japan to join the TBM components and trailing gear that Shank then fabricated and fully assembled on site. It was eventually launched in November last year. Some weekday night work was necessary during the TBM launch, but all noise was kept within the noise limits set out in the environmental impact report.



Above: **Rear of the Shank Hitachi Zosen TBM in action with thrust rams and spoil discharge conveyor [Photo: Jacobs Associates]**

The project team has focussed on being a good neightbour and maintained open dialogue with the local community by providing timely and periodic progress notices, community meetings, and by maintaining a 24-hour 'hotline' to respond to questions and concerens. The team was successful in dispelling early community concerns.

Progress

Once the TBM was launched and joined by the back-up system from the south shaft, progress was better than had been feared, despite frequent breakdowns of the conveyor discharging spoil to rail haulage trucks, Romero reports. Another teething problem was that the shield taper, designed to cope with squeezing ground, made the TBM difficult to steer as shown by laser guidance. To improve steering Shank installed a fin-based anti-roll mechanism that worked, with all initial problems being overcome by the end of December 2009.



Above: **View down the South Shaft showing different types of support [Photo: Jacobs Associates]**

Shank's general manger Jerry Stokes confirms that the TBM started off in good sandstone, and that reasonable drive progress was made despite the concerns over geological conditions. Groundwater make was also surprisingly low in the shafts and tunnel, at around 20g/min. Stokes also says that Shank usually bought their TBMs from Hitachi Zosen as they were prepared to build the shield machines to Shank's design or modifications.

Shank also designed and built a water solids settlement and treatment system on site to ensure the removal of contaminants, especially heavy metals, before site water rejoins the general supply.



Above: **The Shank designed and fabricated TBM back-up gantry running on rails [Photo: Jacobs Associates]**

The TBM installed an expanded pre-cast concrete temporary lining required in anticipation of squeezing ground, but there was little occurrence of this potential difficulty. Mucking out was by the TBM discharge belt conveyor into rail-hauled muck cars that were lifted up the south shaft via a crane-lifted guided platform. A depression at the back of the construction site, adjacent to residential neighbours, could be filled and raised slightly, allowing all 24 000yd^3 (18 350m^3) spoil to be retained on the 3.5-acre (1.4-hectare) site, thus reducing trucking needs.

PROJECT DATA

Client/owner: San Francisco Public Utilities Commission (Regional project manager – Husam Masri)

Design engineers: Arup-Brierley Associates joint venture

Construction management & supervision: Jacobs Associates

Contractor: M L Shank-Balfour Beatty joint venture

TBM: Designed by M L Shank Co and constructed by Hitachi Zosen. Back-up system by Shank

Tunnel dimensions: 1280m long at 1.2 per cent grade. Diameters: 3.71m excavated; 2.44m i.d.

Construction contract bid: USD55.674M

Schedule: Three years to October 2011

From January this year there was a good start after Christmas with an average advance rate on 10h-working of 18.3m (60ft) per day and a record of 25.3m (83ft) per day. Breakthrough to the north shaft was achieved on 24 March, so tunnelling over 1,220m (40,00ft) took three months.

Pipeline installation

Once tunnelling had been completed, installation of the pipeline could begin. Ameron International fabicated the water pipe. The thin-section pipe used at Crystal Springs came in 32-ft (9.75-m) lengths. Shank welded these in the shaft bottom for carrying into the tunnel on a special carrier, also designed and fabricated by Shank within four weeks.

At the north shaft the TBM had been stripped out of all useful equipment to leave the sacrificial shield itself as a temporary support encasing the first length of water pipe. All the steel pipe was in position on 26 May, after which backfilling could begin. A relatively high-density cellular concrete mix was employed by sub-contractors to fill the annulus by placing through holes formed in the steel liner. The heat generated by concrete curing aggravated the warm humid conditions in the tunnel.

The mix was designed and placed to provide sufficient support for the pipe once cured, but to avoid too much flotation force tending to lift the pipe. Even so, the pipe had to be braced internally in its circular section to avoid ovalisation by the competing forces. The whole backfilling operation was scheduled to last two months.

Throughout the project keeping to schedule is of high importance since water supply shutdown periods have to be strictly limited. The contract also carries financial penalties for overruns. The best time for shutdowns is in the winter when water demand is less, so the scheduled completion for the new pipeline this autumn must be met to allow the main supply to be interrupted as the new pipe is connected to the old early in 2011.

Commenting on the project, SFPUC regional project manager Husam Masri says, “we are seismically upgrading and improving the regional water system to prepare for the future. This will provide additional relaibaility to out system ensuring our customers’ needs are met at all times. I am very proud of our project team, both our construction management staff and contractor. They are very committed to quality work and delivering this project on budet and on schedule.”



Above: **The 3.5-acre area on the South of the construction site accommodated all spoil for restoration**



VICTOR ROMERO



As the Jacobs Associates principal in charge of the New Crystal Springs Bypass Tunnel, Victor S Romero is responsible for construction supervision and control on behalf of the client, together with Jacobs Associates associate Sarah Holtz Wilson.

Romero has wide experience in tunnel design as well as construction management in transit projects, pipelines, highways, defence infrastructure and even wine caves. His recent construction management projects include the Cal Park Hill Tunnel and Multi-Use Pathway in San Rafael (see next – September – issue of T&T North America). He was also tunnel design manager on the MetroWest Water Supply Tunnel serving Boston, and led Jacobs Associates' preliminary design on the MuniMetro New Central Subway project in San Francisco.

On the Rio Pedras contract of the Tren Urbano transit system in Puerto Rico he served as tunnel design manager and went on to be resident engineer of construction. Romero graduated as BS in geological engineering from the Colorado School of Mines and was awarded an MS in geotechnical engineering at the University of California, Berkeley.

Jacobs Associates has a broad construction management role for the San Francisco Public Utilities Commission including resident engineering, office engineering, scheduling, cost control, contract administration, quality assurance inspection and environmental monitoring.

San Francisco Water System Improvement Program (WSIP)

The San Francisco Public Utilities Commission is the third largest municipal utility in California and serves 2.5 million residential, commercial and industrial customers in the Bay Area including wholesale supplies to 26 agencies.

The Commission's WSIP is an USD4.6bn programme to repair, replace and seismically upgrade the aging Hetch Hetchey Water System. It includes over 80 projects in seven counties stretching from the Central Valley to downtown San Francisco. The programme is on a tight an unpredictable schedule dictated by nature since the main motivation is to secure water supplies even in the event of a major earthquake. The US Geological Survey predicts a 63 per cent chance of a major earthquake in the Bay Area within the next 30 years, and, at the start of the WSIP, parts of the water infrastructure were approaching 100 years old and/or badly deteriorated and therefore insecure.

The water supply route crosses three major seismically active geological fault systems running approximately north-south: The Calaveras and Hayward Faults to the east of San Francisco Bay, and the famous San Andreas Fault that runs along the San Francisco Peninsula to the west of the Bay. Although most supply routes on the Peninsula run parallel to the fault strike, some supplies inevitably have to cross the fault to serve communities on the Pacific Ocean coast. Some supplies are also drawn from reservoirs on the fault zone including the Crystal Springs Reservoir (above).

The 1903 Great San Francisco Earthquake and Fire is still present in the collective consciousness, if not the memory, of San Franciscans, and the City is determined not to be short of water following a seismic event again. While a regional water delivery system is now in place, the much larger population means that a long-term cut in water supplies for fire fighting and drinking could be catastrophic.

Construction is underway or completed on over USD1bn of projects, the largest of which take place from last year to 2015. As with the existing system, the improvements are almost entirely gravity fed, i.e. use minimal pumping and thus little energy for transmission. This is just one example of environmental considerations for which California is famous. Each project undergoes specific environmental reviews and, on average, will require four to five permits from regulatory environmental agencies before progressing.

Major projects imminent within the WSIP include the Bay Tunnel and the new Irvington Tunnel. Jacobs Associates led the design for the Bay Tunnel, which is being managed by Jacobs Engineering (a separate company) during construction, and Jacobs Associates also worked on the design for the New Irvington Tunnel, for which construction management is being provided b Hatch Mott MacDonald.

A joint venture of Michaels, JayDee and Coluccio was awarded the USD215.3M contract in January to construct the Bay Tunnel and recently received notice to proceed, and are commencing mobilisation on site. To give the overall project its fuller name, the Bay Division Pipeline (BDPL) Reliability Upgrade Project is valued at USD332M and includes three major water infrastructure projects. The third of these is the 8-km (5-mile) Bay Tunnel to carry water under the south end of San Francisco Bay in what will be the first bored tunnel under the Bay, at depths of down to 30m (100ft).

This tunnel, to be driven by a 4.27-m (14-ft) o.d. EPB TBM, will link the existing portions of BDPL Nos. 1 & 2 (dating from the 1920s and 30s). These either lay on the floor of the Bay or are mounted on trestles over environmentally sensitive marshland. All are deteriorated. The finished tunnel will carry a welded steel pipeline concreted in position to form a 2.7m (9-ft) finished diameter. At each end vertical shafts will connect the Bay Tunnel to pipeline manifolds for BDPL Nos. 1, 2 & 5. Spoil removed from the tunnels and shafts is expected to be used to restore old salting ponds to marshland. The portion of BDPL Nos. 1 & 2 replaced by the tunnel will be capped at each end and left in place.

The New Irvington Tunnel Contract was awarded in June to a joint venture of Southland Contracting of Fort Worth, Texas, and Tutor/Perini of Sylmar, California at a lowest bid of USD226.6M, and notice to proceed will be forthcoming late this Summer. Construction is expected to begin in September this year for completion in early 2014. The New Irvington Tunnel will lie parallel to the original tunnel between the San Antonio Reservoir and Fremont on the east side of San Francisco Bay, and has the purpose of providing a seismically upgraded connection between water supply sources from the Sierra Nevada Mountains and the Almeda Watershed through to the Bay Area. The new tunnel will be 5.6km (3.5 miles) long and 2.6-3.2m (8.5-10.5ft) in diameter. It will also allow SFPUC to take the existing tunnel out of service for 'much needed' servicing.

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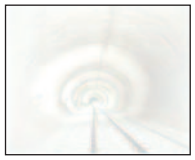
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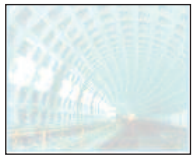




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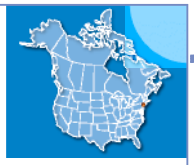
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Never so bored in NY

New York's East Side Access (ESA) rail project has used a pair of TBMs to help cavern construction by lancing repeatedly into the rock below Manhattan. Report by Patrick Reynolds

On winning a second tunnelling contract on the East Side Access (ESA) rail project in New York, joint venture contractor Dragados/Judlau decided to minimise the drill and blast needed for large cavern excavations below Grand Central station by taking advantage of a pair of TBMs already in the ground to drive the approach tunnels.

But while the logistical demands on drill and blast mining would be dramatically reduced, the contractor, having already faced a significant logistical challenge in getting the TBMs and backups below ground, was going to double the number of drives. The change would demand repeated, and phased, recoveries and retractions of the machines.

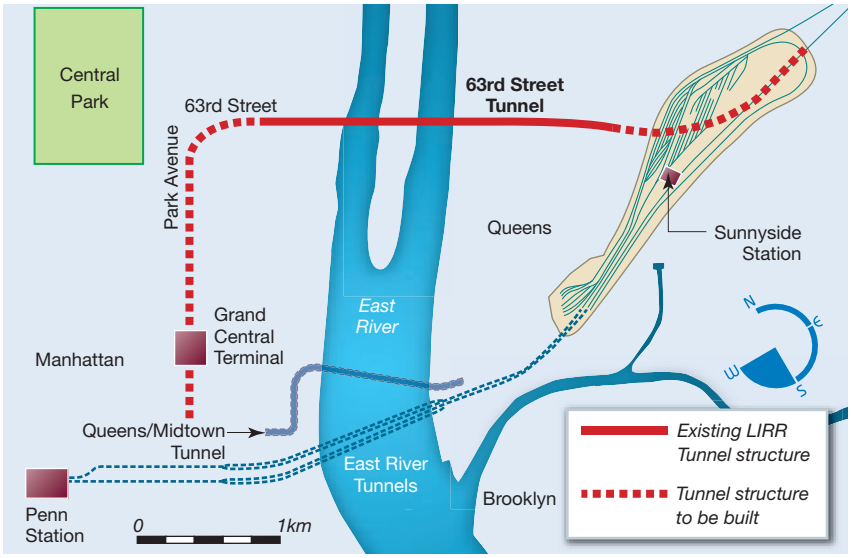
With the bores underway, stretches of weaker ground have led to slower progress at times for the TBMs, both advancing and when pulling through heavily-supported areas, further complicating the logistical challenge. But the majority of the 10km (approx.) of tubes have been bored. One TBM has completed its work, and the caverns are being opened up further, albeit more slowly than planned, and a major push is underway to accelerate progress.

The ESA project

ESA is being developed by the New York's Metropolitan Transportation Authority (MTA) to join Long Island Rail Road (LIRR) via Queens and East River to Grand Central station in Manhattan. The project is a resurrection of a plan, stalled due to lack of funds in the '70s, but leaving a 2.6km long tunnel from Queens to the edge of Manhattan, partly twin bore and also including an immersed tube in the East River.

The resurrected scheme, which is budgeted at approximately USD3bn, involves tunnelling works at either end of the existing tunnel, in Manhattan and Queens (see box).

MTA's Capital Construction (MTACC) division is being supported on three levels by consultants: URS on programme management; a JV of Parsons Brinckerhoff, STV and Parsons as general engineering consultant (GEC); and, a JV of Jacobs' Edwards & Kelcey division with LiRo on construction management services.



Top: **Figure 1A - Map of the new tunnels in Manhattan and Queens to connect with the existing Long Island Railroad (LIRR) tunnel**
Above: **Figure 1B - Tunnel drives layout plan and sections through chambers**

Manhattan Approach Tunnels

The major tunnelling works in Manhattan are the Manhattan Approach Tunnels (MATs) to Grand Central and two caverns below the station that will form a new terminal, currently due in service by late 2016. The distance from the existing tunnel that includes the MAT stretch, the station and extends to the dead-end tail track tunnels beyond, is 2.2km.

ESA's myriad tunnels and caverns in Manhattan are excavated in schist and gneiss, the underground structures ranging in depth from about 25m-52m and in a high water-table.

MTACC let the MATs and cavern packages as separate contracts, CM009 and CM019, respectively. Both contracts were won by Dragados/Judlau in late 2006 and early 2008. The JV then integrated the excavation plans for each contract.

Under CM009, the approach tunnels are designed as parallel tubes that then



Above: **The Seli TBM holes through at the 37th St 'wye'**



Above: **Cavern looking northwards with**

bifurcate into upper and lower bores. To construct a tunnel pair, a tube is bored to a terminal cavern and the TBM retracted as far back as a GCT5 wye ("Y") junction, which by then will have been opened up. The first tube forms the upper tube, and TBM is relaunched to bore the lower tube. There is a 131m long wye for each tunnel.

In terms of layout, near the ends of each drive are structures that will enable track switchovers for trains entering and leaving the future terminal, which will have eight platforms served by the four tubes. The shotcrete-lined structures, therefore, are common to the different TBM drives at key points and sometimes require concrete plugs for launches. They are:

- crossover caverns (GCT3-upper level, GCT4-lower level), which are 97m and 119m long, respectively, and are up to 15.8m wide and range from range in height from 7m-10m; and,
- further wyes (GCT3-upper level, GCT4-lower level), which are each 97m long.

Geology along the alignments of the MATs comprises schist with gneiss, granite and marble of UCS 80MPa to more than 200MPa, and they belong to the New England Upland or Manhattan Prong formation.

ESA - Queens Tunnels

In Queens, the final approach to the existing East River tunnel is to be constructed below a rail storage yard using a pair of slurry TBMs to bore four tubes with a combined length of slightly more than 3.2km.

The contract (CQ031 – Queens Bored Tunnels and Structures) was awarded in late 2009 to a joint venture of Granite Construction Northeast, Traylor Bros and Frontier-Kemper Constructors. The award was valued at USD 659.2M and the works, including excavation of three emergency exit structures, was estimated to take 42 months.

In the client's report on ESA to the Federal Transit Administration (FTA) that covers Q1, the current approved contract was valued as USD 717.6M. Assuming contract options will be exercised, the final value of the contract is estimated at almost USD 757M. Funding from FTA for part of the contract includes a contribution from the American Recovery and Reinvestment Act.

Both planned and forecast targets for substantial completion of the tunnelling works remain the same – September 2012 – notes the Q1 report. It adds that the spend was under budget, and noted that the original scope of work was delayed so the contractor could undertake slurry wall repairs, under a change order, prior to open-cut excavation.

The soft ground TBMs are due to arrive on site in late summer, says MTA.

TBMs – Back & Forth

Two 6.7m diameter hard rock TBMs were acquired for the contract - a Robbins main beam and a refurbished double-shield from Seli, originally manufactured by Robbins. Tunnel support is in situ concrete in the worst areas and elsewhere ribs, bolts and mesh, in addition to grouting following probing and draining. The final concrete lining is to 5.95m diameter

Getting the bores started was a logistical challenge in its own right. The contractor could not open up large assembly caverns for the TBMs and backups due to restrictions from neighbourhoods, limited available space and the proximity of live subway tunnels. There were also some restrictions on using drill and blast.

A further complication was the assembly chambers being so close and having weak rock separating them, holding up part of the drives, and calling for reduced gripper and thrust pressures when TBMs were launched; first the Seli TBM and then the Robbins machine, in late 2007.

The Seli TBM was launched on the eastbound tube with a preliminary configuration. After 200m the machine had advanced to reach its final configuration.

Robbins' TBM was designed for a two-stage assembly process with a long, inner core brought into the small chamber where the outer parts, including sections of cutterhead, had been pre-positioned in a ring in the chamber.

So, another design feature of the TBMs



the Seli TBM on the left



Above: **Behind the Robbins TBM shield with discharge conveyor**

was to have them capable of being retracted along the bored tunnels while enabling the trackwork, utilities and initial supports to be kept in place, with only ventilation ducting requiring deflation. The Robbins TBM could be stripped back to its inner core with a reduced cutterhead just over 6m wide, and the shielded front section could be folded and the front shoe collapsed. Seli's shield has a self-collapsing arrangement of retractable shield cans.

Bores multiply

The joint venture won the CM019 (Manhattan Structures 1) contract only a few months after both TBMs got underway. The main works are the terminal caverns but additional activities include building shafts, escalator wells, air plenums, cross passages and, beyond the terminal caverns, the GCT1 & 2 wyes and tail track tunnels, which are dead-ends for switchover of trains.

The terminal caverns are about 35m long by 18.3m wide and 21.3m high, and the finished structures will have cast-in-place concrete arch roofs that are self-supporting off rock ledges. The GCT1 & 2 wyes are 100m long and vary in cross section at 9.1m-15.5m and heights of 18.3m-19.8m.

Simply, the joint venture's plan was to take the four tubes already approaching the caverns under CM009 contract and form further bifurcations for each. This would result in eight bores through the caverns and then, beyond, they would be returned to four tubes for the tail track tunnels.

The new boring sequence would begin, as before, with the upper drive approaching the cavern and it would proceed further, be retracted to a GCT3 wye – by then partly opened up – and relaunched. These would be drives 1 & 2 (D1 & 2). Either could be the short tube passing only through the cavern or the long tube, which includes excavation of a tail track tunnel.

The TBM would then be retracted all the way back along the original approach tunnel to a GCT5 wye and relaunched again to bore the lower approach tube. The same procedure at the cavern would create drives D3 and D4.

In the tunnel drive layout plan (Fig 1B), the respective tubes by the Seli drives (SD) and Robbins drives (RD) are shown as SD1-4 and RD1-4. So, in total the sequence has four launches for each machine, and temporary concrete plugs are



Left: **The Robbins TBM with partial cutterhead in transit to the chamber**



Left: **Erecting support mesh inside the Seli TBM**

used in opened junctions to help the process. The first of the two Robbins drives at each level of the west bound terminal cavern were the longer of its tube pairs whereas, for the overall sequence, it was the opposite for the Seli shield.

The cavern excavations are proceeding with mining methods following the TBM bores. A series of headings and benches will take out the remaining rock, and all top TBM bores have been completed.

Progress

Aside from the logistics of the multiple TBM movements – including when a TBM having to await others due to the need to remove concrete plugs at junctions, the progress of the tunnelling works have sometimes faced challenges of weaker ground than anticipated. This caused further problems to retract through heavy supports in places, sometimes needing other structures.

The mining operations in the terminal caverns have been progressing slower than planned, and changes to activities and sequences are helping to pick up the pace.

MTA's most recent available quarterly report on the project to the Federal Transit Administration (FTA), covering Q1 to March, says the last of the eight bores – SD4 – is due to finish by mid-2011. The SD3 bore is almost finished, and the RD bores were completed two months ago.

Progress - CM009

While the two contracts, CM009 and CM019, are proceeding with an integrated excavation plan, the Q1 report to FTA notes that substantial completion of the main bores and other underground structures under CM009 is expected in September 2012, slightly later than the already revised target of April that year.

The June report to the MTA Capital Program Oversight Committee (CPOC) notes that TBM excavation under CM009 was one per cent ahead of its planned excavation rate and that overall work was 70 per cent complete. The TBM work was within the latest revised schedule and does not put pressure on the substantial completion date.

The cost expenditure for CM009 was noted as being on target at just over 68 per cent. The original contract award was USD 427.9M, the current approved contract was USD 443.4M at the end of Q1 and the estimated final value of the contract is USD 450.3M.

Progress - CM019

From the Q1 report to FTA, the forecast and target dates for substantial completion on CM019 are September and April 2012, respectively. The original target deadline was about March/April 2012, and the revised programme had reset it to August.

Underground excavation was, by late May, almost 20 per cent complete, excluding the contribution by TBMs and activities at Madison Yard, notes the June CPOC report. It adds that cavern excavation rates have exceeded the baseline assumption, helping to regain some lost time in the overall tunnelling works.

However, it notes further that the overall rate for non-TBM excavation was only about three-quarters the planned rate. The rate was an improvement over the excavation having been 28.5 per cent behind the planned volume, as noted in the March CPOC report. Most delays were blamed on works in the East Cavern, which is on the critical path of the CM019 contract.

The milestone of completing the top heading of the West Cavern is forecast to be achieved in November, slightly ahead of plan. To pick up pace, a revised approach to excavation, trialled on the East Cavern, is now being employed which involves using a crusher as well as parallel excavation by roadheader and drill-and-blast.

In addition, delayed current activities including work at locations such as cross passages, wyes and other ancillary spaces started over April/May with resources then made available, it says. To help progress further, MTA has also relaxed the blasting criteria and provided the contractor with greater flexibility, it notes in the March CPOC report.

In the June CPOC report, it was noted that excavation would resume over May/June in the top heading of the tail tracks, GCT3 crossover and GCT1 & 2. This quarter, excavation is to get going again at other locations including GCT4 as well as GCT 5 (on CM009).

The original contract award for CM019 was USD 499.9M, and by the end of Q1 that actual cost expenditure was below plan. The current approved contract value, at the end of Q1, was USD 528.4M and, assuming contract options will be exercised, the final value of the contract is estimated at almost USD 780M.

Progress – Options Ahead

The Q1 report to FTA notes that the client's project team was working with the contractor on both contracts to mitigate delays and recover schedule, such as not retrieving the TBMs via the Queens pit but instead possibly burying them.

Also, cost saving opportunities were being checked on contract CM009, such as using shotcrete as a final liner for non-uniform structures and a revised geometry of the GCT3 and GCT5 wyes. On the contract CM019, potential cost savings from revising the geometry of GCT4 were also under review.

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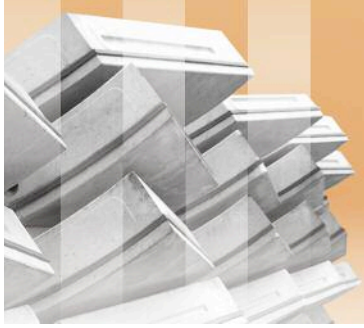


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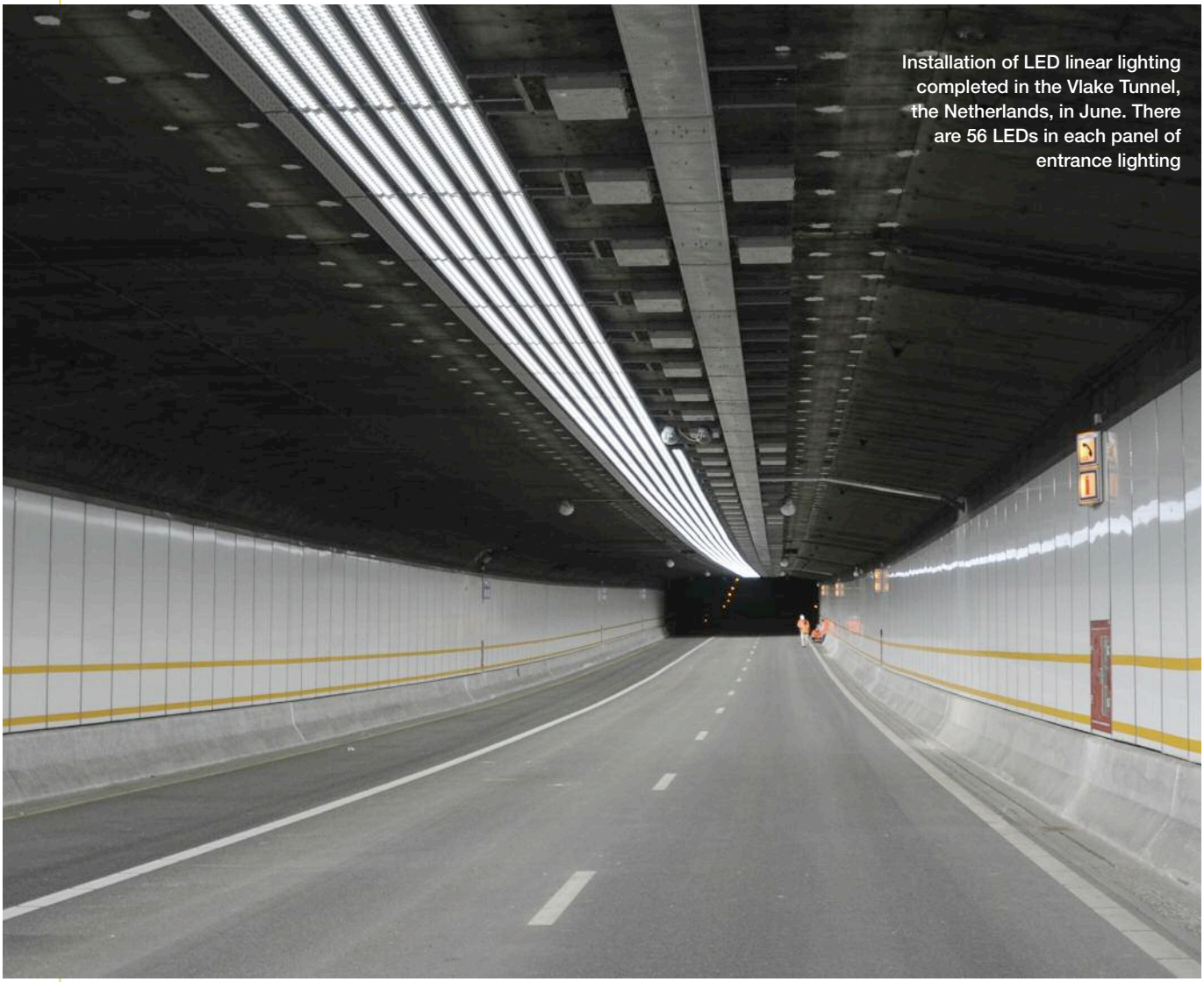
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Installation of LED linear lighting completed in the Vlake Tunnel, the Netherlands, in June. There are 56 LEDs in each panel of entrance lighting

LEDs leading lighting

Following a renovation that finished in June, the Vlake Tunnel is now the first in Europe to be fully lit with LEDs and the first to use LED linear lighting, Nicole Robinson reports.

The 774m Vlake Tunnel is located in the Netherlands on the A58 highway, below the channel through 'Zuid-Beveland.' It comprises two tubes, each with two lanes and one emergency lane, and a 1m wide work zone between the tubes. Originally built between 1972 and 1976, the tunnel saw its last renovation in 1992—prior to upgrades completed early this summer including installation of LED (light-emitting diode) linear lighting inside and LEDs for the traffic control lighting outside.

On the whole, this most recent work needed to renovate an outdated system, preparing the tunnel to meet future Dutch and wider regulations and replacing the remote control from its location in Wemeldinge to Geldrop. Initially, an LED solution wasn't intended for the lighting, but it was something Willem Zandvliet had been thinking about. Working for Rijkswaterstaat, the organisation that manages and develops the main national infrastructure facilities on behalf of the government, he is involved with its ZekerDuurzaam (or using less energy) programme.

It started as an idea to save energy by bringing light in the tunnel where it is needed, explains Zandvliet, not to lose light in reflectors or the protective glass, bringing the LED light directly where it's needed with small lenses. "This is only possible because LED light is a very



The lines of entrance lighting reduce toward the tunnel's exit

small light point so you can also use small lenses," he says.

To test the concept of using LEDs, a feasibility study was started in April 2008 through LedExpert and Nico de Kruijter, a light consultant. "The final conclusion of the feasibility study made clear that LED tunnel lighting was possible but at the moment there were no lamp suppliers," he says. Meanwhile, the project's contractor, Siemens, made a successful offer in September 2008 that included conventional lighting in combination with a daylight grid.

The ZekerDuurzaam approached Indal, which it has worked with previously, to be the supplier and offered the Vlake Tunnel as a pilot project. It was the best opportunity to test the concept because Siemens was already doing the renovation work, says Zandvliet, though, changing the contract with Siemens was a big risk to take. The decision in September 2009 to use LED linear lighting also left Indal with a tight deadline to develop the product, test it, produce it and deliver it for January 2010.

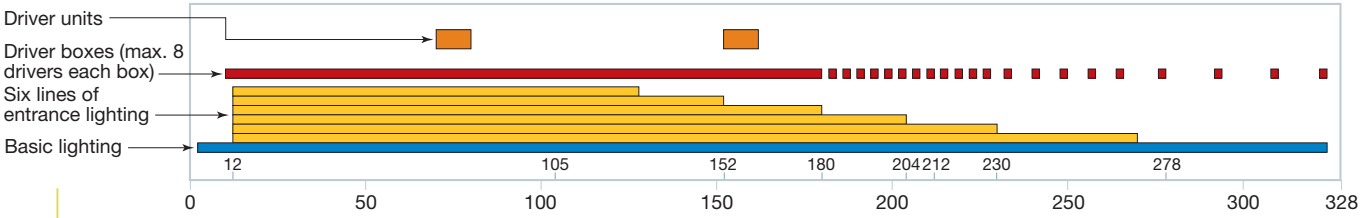
Installation took six to seven weeks, with four weeks spent working on the first tube and only two and a half on the second after Siemens found the most efficient way of working. The tunnel opened to traffic in mid June, with a reduced speed limit of 90km, which will change once the users in the area are used to it.

Indal estimates the Vlake Tunnel will see a 30 per cent reduction in energy use, but notes that when it comes to comparisons, the original and new schemes are not identical. The previous scheme didn't have enough of a transition (going toward the exit), and the new scheme has corrected this adaptation zone.

T-line

The LED linear lighting in the Vlake Tunnel comprises one line of basic lighting that runs the whole length and six lines of entrance lighting, which reduce gradually as the lines reach the exit of the tunnel. Each T-line segment is powered by a driver, of which eight are stored in a driver box, and boxes are connected as driver units. Indal's T-Line is available in two versions, a 40 LED for interiors and a 56 LED for entrance lighting—used for the basic line and the six entrance lines of the Vlake Tunnel respectively.

For road tunnel applications, there are



two options besides Indal's T-line; traditional HPS (high-pressure sodium) point source lighting or fluorescent linear lighting, explained Indal's product manager for tunnel lighting Jeroen van der Vlugt. So the T-line has been designed to combine the comfort and safety of the fluorescent option with the lower total cost of ownership of HPS point source.

Lighting from linear fluorescent applications is more uniformly shed on the walls and road and is a cooler, white colour. This is more comfortable for drivers because there are no dashboard 'flashes', no sharp moving shadows and no flickering effect, compared to the more yellow colouring and shadows created by HPS point source lights that are spaced apart, van der Vlugt explained. On the other hand, HPS is a cheaper option when it comes to the cost of the luminaires and their installation, the cost of energy and the costs associated with lamp replacement.

What Indal has taken is the linear lighting concept—installing T-line one after another without any space between for continuous illumination—and using LEDs for their white light, lower energy consumption and longer lifetime. Because maintenance of the T-line doesn't require lamp replacement, only high-pressure cleaning, the total cost of ownership for an application is quite close to that of the HPS option.

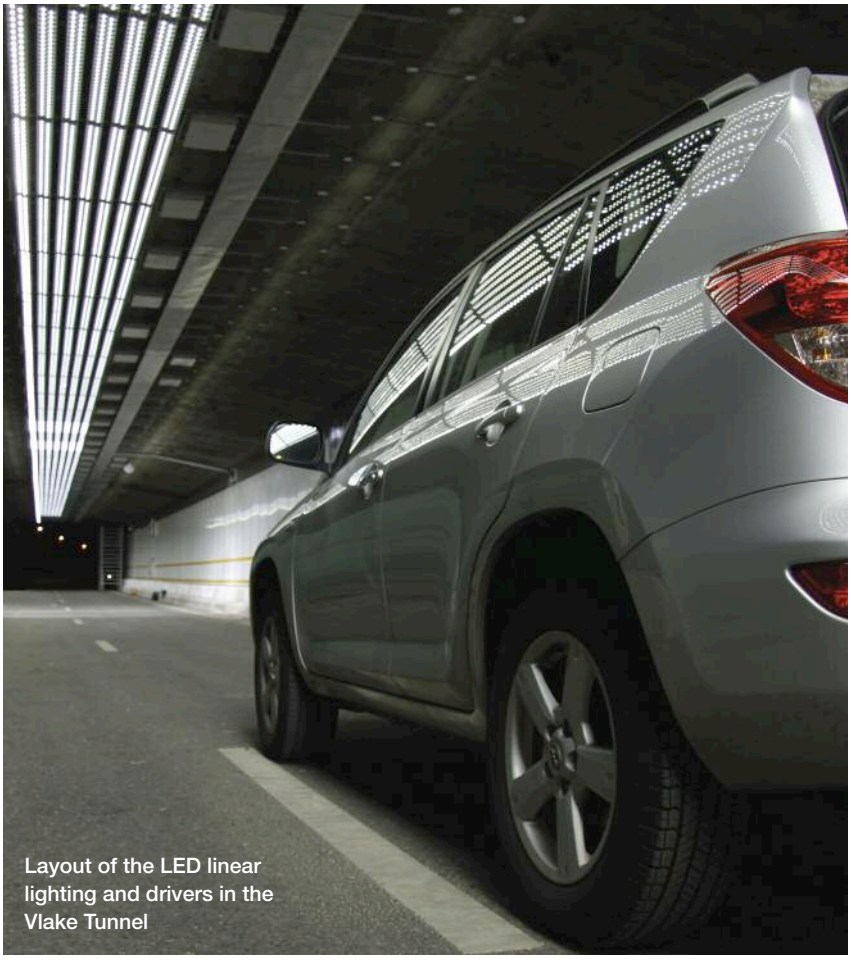
Future standards

In the UK, the first trial of T-line lighting will be installed in the Upper Thames Street Tunnel in London later this year. "But unlike the Vlake Tunnel, the original SON Cornice lighting will be temporarily left in situ and switchable," says Steve Ryan, tunnels technical manager with Transport for London (TfL). "This will allow TfL to gather comparison data on lighting performance, tunnel user perception with regards to colour, intensity and safety along with energy consumption."

Data gathered from this project will also be good for developing standards for LED lighting in tunnels, he explained.

Project requirements for the Vlake Tunnel had originally been based on conventional lighting, and requirements for LED highway lighting are not yet available. Indal developed the LED tunnel light installation according to the advice of the European CIE-tunnel lighting standard guidelines. The Vlake Tunnel would, according to new requirements, not have a daylight grid, have continuously adjustable lighting from 10 to 100 per cent and meet the requirements of the Dutch Foundation of Illumination (NSVV).

Because the Vlake Tunnel's lighting can be dimmable down to 10-15 per cent, it can match the various ambient conditions during the day and night. The tunnel can even be lit using just the basic interior lighting alone—and not the six lines of entrance LEDs. Future developments in LEDs will increase their efficiency, explained Indal. For example, the illumination now provided in the Vlake Tunnel by six rows could be provided by only three. From a system perspective, Indal expects developments allowing lighting on demand, only when necessary and the exact amount. And in the future, integrated tunnel design where elements like the tunnel portal design, road surface and wall materials and the design speed and tunnel class will factor in the use of LEDs.



Layout of the LED linear lighting and drivers in the Vlake Tunnel

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The Herrenknecht Pipe Thruster for assisting the installation of long steel pipes

The jacking of pipes and other structures to create underground space is something of a Cinderella pursuit compared to the more glamorous, 'sharp end' activities of TBMs and drilling, yet it occupies an important place in our overall industry. Maurice Jones takes a look at the current state of technical development.

Still thrusting forward

Pipe jacking has been around a long time since it was first developed in the US with steel pipe in parallel with the widespread use of auger boring to pass utility lines under surface obstructions. Together with related techniques and terminology such as tunnel jacking, culvert jacking, structure jacking, and even bridge jacking, it provides an important range of techniques for creating, usually longitudinal, space from A to B.

It is important to note that it is primarily a support method for the final excavation, plus a means of carrying out its duties (e.g. sewerage or water transmission). However it is also inextricably linked with the means of excavation (mechanised or manual) and the use of the final structure to transmit the forces necessary to force the string of pipes or final structure through the ground, and perhaps the means of mechanised excavation as well, such as a shield machine. It can be seen that this places a lot of structural demands on the pipes, or whatever, being installed.

With the increase in mechanised methods there have been many adaptations of the basic technology, and overlaps with others such as auger boring and microtunnelling (of which it is part) and remote control tunnelling. It should not be confused with pipe ramming, or even pipe thrusting, in which there is no excavation of the ground within the pipe until it is fully installed.

Problems to overcome

In recent years research and development have been concentrated on overcoming the formerly frequent problems that could jeopardise a successful installation operation. These problems, and solutions, include overcoming friction (lubricants and how to apply them), improving soil properties (polymer conditioning, etc), negotiating both horizontal and vertical curves (guidance and monitoring), longer drives, and reducing the thrust loads on pipes (intermediate jacking stations, lubrication, etc). Failure to address these problems properly can easily result in pipe cracking or total failure requiring difficult, or maybe impossible, replacement work and possible rejection of the final structure.

In conjunction with this there has also been substantial high-level research into understanding the nature of the interaction of the equipment, pipes and the ground being passed through, whether along the pipe or at a mechanised face, and how this might be improved for greater efficiency and security. There has also been work on improving pipe design to withstand the loads involved; although there have been suitable pipes available on the market for many years providing they are matched correctly to the equipment used.

Lubrication

The properties and uses of bentonite are well known in the tunnelling and drilling industries, and these include the lubrication of exterior pipe walls when jacking. A major advantage is that the bentonite mix, based on a natural clay, is generally chemically inert and non-polluting. The bentonite slurry in injected through valved pipes in the installed pipe walls at the required intervals through the pipe 'string' being jacked. After hydrating the mix adequately using high shear mixing, delivery is by positive displacement pumps.

At first injection was manually controlled as required when excessive friction was encountered, but automatic injection according to planned performance of the whole operation has been used in recent years. Belgium-based specialist contractor Denys reports it has been using automatic lubrication for more than seven years.

The bentonite lubricant mix must be right for purpose and a trial mix should be undertaken. The CMS Pozament division of Tarmac recommends that for pipe jacking one tonne of dry bentonite will produce 12.8m^3 of slurry.

Load monitoring

While it is easy to measure the pressures in jacking equipment, it has previously been difficult to assess the actual forces to which pipes are subjected, especially, for example, when a substantial distance from the jacking station or on a curve or misalignment.

In conjunction with the Aachen RWTH, Herrenknecht has been developing a pipe joint sensing and monitoring system called the Online Load Control (OLC). It has already been used in some pipe jacking applications including the Maerzenbach hydropower scheme in the Austrian Alps. Using an AVN1600TB mechanised shield,



Above: **Inside the first planned curved pipe jack in the United States [Photo: VMT]**

the 1970mm-diameter pressure pipe was jacked 863m in usually hard, abrasive ground. The route included vertical and horizontal curves, a difference in elevation of 80m and at depths as much as 80m. The OLC senses and identifies critical loads at the installed pipe joint and calculates the maximum allowable jacking load in real time.

Pipeline push

Another recent development by Herrenknecht combines features of pipe jacking with horizontal directional drilling rigs. The Pipe Thruster assists the installation of 'continuous' steel pipelines that, with conventional directional drilling, would rely mainly on the pullback force available from the drilling rig.

A recent application was for passing a 'continuous' casing pipe for a gas transmission pipeline under the Godavari River in Rajahmundry, India. The contractor, Zueblin International, used the 550-t Pipe Thruster on either bank of the river to reach an island revealed in the centre of the river during the dry season. A total of 2475m of 48in.- (1220mm) diameter casing pipe was installed successfully at higher progress rates (up to 5m/minute) than conventional means, allowing the job to be completed before the next monsoon and flooding of the central island.

Sorting slurry

The UK Pipe Jacking Association (the PJA) and its members have supported many research programmes including the work on soil behaviour, friction and pipe loading at Oxford and Cambridge universities outlined above. It also works with the key bodies involved with UK education and training, specifications and standards including, also, the departments of civil engineering at Leeds and Newcastle universities as well as Oxbridge, the BSI and CEN, the Constructon Industry Training Board, the BTS, TRL and H&SE.

The latest programme is to tackle a problem common to many tunnelling projects: efficient management and disposal of spoil, especially slurry. Depending on the amount of fines, it can take a long time for excavated material, aggravated by clay, to settle out in tanks, even with using flocculant. This may result in the need for cyclones, filters, and presses to separate solids and water. In addition there may be requirements for water treatment before discharge, all increasing the overall costs. Thus any measures that can economically improve separation procedures are to be welcomed. This does not remove the need for increasingly valuable disposal sites, but it may reduce the volume needing to be disposed of.

Intelligent guidance

The scope of pipe jacking is greatly increased if the route is not restricted to a straight line, vertically or horizontally. Conventional laser guidance allows adjustments to keep a straight pipe jack on route, but more sophisticated systems allow the installation of curves to pass under obstacles, follow curved surface routes, or avoid deep foundations. Curved mechanised excavation pipe jacking (microtunnelling or remote-control tunnelling) has been practised, where required, for many years in Germany and Japan. Recently VMT announced completion of what is believed to be the first planned curved microtunnel in the US. Northeast Remsco Construction completed a 183m (600-ft) drive including a 414m (1359ft)-radius bend in nine days using a Herrenknecht AVND 1800AB MTBM fitted with a VMT SLS microtunnelling LT guidance system. The purpose of the curve was to avoid known complex obstacles on the route, necessitating several revisions of the route.

Moveable structures

The installation of relatively large-dimension, often rectangular-section, structures such as culverts, underpasses and subways under surface obstructions such as roads and railways, which may remain active, is something of a niche pursuit within the jacking world. As such there are a few well-known practitioners with key experience. These include the contractor BAM-Nuttall (Doug Allenby), John Ropkins and James Thomson. Not only are the sections installed much larger than with conventional jacking, they can also be inserted close below the existing infrastructure.

James Thomson has been involved with jacking pipes and structures since the 1960s, having pioneered jacking in the UK and Singapore, and developed various techniques for structure jacking including the drag-sheet to reduce friction; a possible major problem when trying to avoid damaging interaction with adjacent structures such as a railway. He has recently set up a new company, Jacked Structures SA, in Geneva to specialise in offering engineering and construction management expertise. Jacked Structures points out that jacking can be used to create irregular openings as well as the more usual regular sections in large dimensions.

John Ropkins has worked on some of the largest projects including jacked box tunnel sections for the 'Big Dig' highway project in Boston, US, the largest jacked box tunnel in the UK at Downey, near Maidenhead (with Nuttall), and the first jacked box tunnel under a motorway in the UK, at the MI junction 15A, Northampton.

Future coverage

Tunnels & Tunnelling International will be returning to the subjects of pipe and structure jacking in the future, starting with a feature in our next (September) issue on major railway construction in the Brussels suburbs by Denys of Belgium. The report describes not only large-diameter (DN3000mm) mechanised pipe jacking, but its use in creating larger underground structures including pipe-roof construction with microtunnelling.



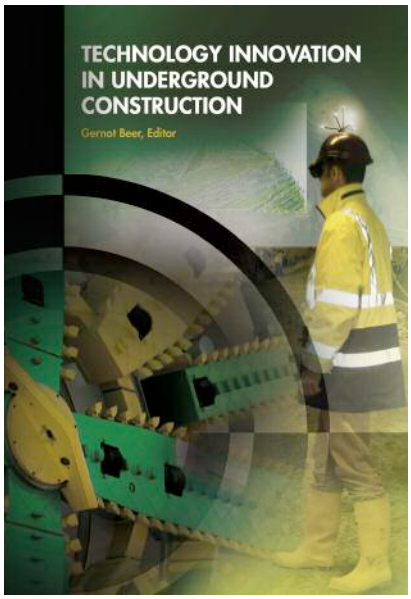
Right: **Pipe jacking as used to create a larger underground structure for a Brussels rail route (see September issue for full story) [Photo: Denys]**

Tunconstruct reports

Maurice Jones reviews 'Technology Innovation in Underground Construction', Editored by Prof Gernot Beer of Institute for Structural Analysis at Graz University of Technology and Published by CRC Press/Balkema, The Netherlands

With a EUR25M budget, the European Commission (EC)-funded Tunconstruct project has been one of the bigger integrated projects (IPs) under the 6th Framework Programme for research and development. It has 41 participating groups from 11 member states examining a wide range of advanced technologies that are, or should be, applicable to modern tunnelling. The two overall aims of the EC in this regard are to make European industry the most competitive in the world, and to establish a European Research Area (ERA).

This collection of reports from participants is edited by Prof Gernot Beer



of the Institute for Structural Analysis at the Graz University of Technology, Austria.

Participants include commercial engineering practices, contractors and manufacturers as well as more academic research organisations, thus reflecting the whole range of expertise types available to the industry. The development subjects are mainly computer-based. The chapter on Underground Construction Information Systems (UCIS), already beginning to be commercially available, features Geodata's Kronos monitoring and alarm system.

Subsequent chapters discuss computer support for the design of underground structures including workflow, time and cost factors; 'virtual reality' visualisation of underground construction; and the combining laboratory, geological and TBM data into simulation models plus process-oriented numerical simulation including conventional as well as TBM excavation.

Prediction of and reaction to discovered geological conditions occupy several reports including the use of optical fibre sensing cable to monitor underground settlement, and the seismic exploration and geological mapping of the ground ahead of TBMs. On the practical operation of tunnelling machinery there are reports on advances in TBM steering by STUVA, Hochtief and the Ruhr University, reduction of the environmental impact of tunnel boring using the Oscar physical simulator developed by Bouygues and Sika; TBMs for very large tunnel profiles by Herrenknecht, and optimised rock cutting for both TBMs and roadheaders with reports from Sandvik with research organisations in Poland and Spain.

Support is not forgotten either with reports on the use of micromechanical material models to assess the safety of sprayed concrete tunnel shells, pre-cast segment behaviour during tunnel advance and the development and testing of high-performance segments, soil grouting using tube-á-manchette installation by horizontal directional drilling, real-time monitoring of the concrete spraying process, and innovations in the mixes used and environmental considerations in spraying concrete with reports from Spain.

There is even a report on tunnel maintenance using robotic inspection and repair using systems developed by Dragados, Sika and RoboticsLab of Spain.

There is only one minor criticism of the publication. The colour plates, that in many cases enhance the understanding of the work reported on, are all collected at the back of the book. No doubt this reduces publication costs, and there are mono duplicates in each text, but their impact and usefulness is reduced by their position.

Nevertheless the publication, with mainly clear diagrams, is a major contribution to knowledge on advanced tunnelling techniques, and should also be noted by those in positions of power that sill think that tunnelling is a nasty, dirty, low-tech pursuit. As Martin Knights, Past President of the International Tunnelling and Underground Space Association, says in his 'Editorial' to the book, "The next challenge is to progress the findings of the project." No doubt those developments that offer clear economies in construction will attract attention but those more advanced concepts that may improve overall project efficiency, or increase the scope of underground construction, are also well worthy of attention. To those who think the use of virtual reality in tunnelling somewhat fanciful, may we remind them of the general development from tunnelling as an art to a science including such, now commonplace, techniques as numerical analysis, laser-based guidance and monitoring systems, remote-control shield and loading machines, improved accuracy in subsidence control, and 3-dimensional design and visualisation.

Beer at the Conference



Prof Beer will be one of the leading international speakers at the Tunnels & Tunnelling International Conference at the Institution of Civil Engineers, London, on 28th September. In addition to presenting a review of the Tunconstruct project and the developments described above he will provide more detail on advanced visualisation and numerical design techniques, and their place in modern tunnelling.
For more information on delegate registration and participation in the select accompanying exhibition, contacts head of sales Shelly Palmer on +44 (0)207 936 6848 or email spalmer@tunnelsonline.info.

dates & events

18 - 20 AUGUST 2010
9th Tunnel and Underground Engineering Academy and Technology Cross-Straits Seminar, Luoyang, China
Celebrating 100 years of the Chinese Civil Engineering Society
Contact: Ms. Zoey Yao
Tel: +86 21 62278931
Fax: +86 21 62278358
Email: zoe.yao@merisis.asia.com

5 - 10 SEPTEMBER 2010
IAEG Congress 2010, Auckland, New Zealand
Contact : PO Box 90-040, Auckland, New Zealand
Phone: +64 9 360 1240
Fax: +64 9 360 1242
E-mail: iaeg2010@tcc.co.nz
web: www.iaeg2010.com

21 - 24 SEPTEMBER 2010
InnoTrans 2010, Berlin, Germany
Unternational Trade Fair for Transport Technology
Innovative Components - Vehicles - Systems
"The future of mobility"
web: www.iaeg2010.com

22 - 24 SEPTEMBER 2010
TBM Technology for Large Diameter Tunnels - Tunnelling short course, Colorado, USA
Information and registration on the conference website:
www.tunneling.com/topics/tunneling_course_outline_2009.htm
Organised by: Colorado School of Mines
1500 Illinois St.
Golden, CO 80401

23 - 27 SEPTEMBER 2010
ISRM Symposium and 6th Asian Rock Mechanics Symposium, New Delhi, India
Symposium secretariat:
Central Board of Irrigation & Power
Malcha Marg, Chanakyapuri
New Dehli 110 021, India
Contact person:
Mr. V. K. Kanjlia, Member Secretary, Indian National Group of ISRM
Phone: +91-11-2611 5984/2688 2866/2410 1591
Fax: +91-11-2611 6347
E-mail: uday@cbip.org; cbip@cbip.org
Web: www.arms2010.org
Download First Bulletin

28 SEPTEMBER 2010
Tunnels and Tunnelling Conference
T&T, in partnership with the British Tunnelling Society will be bringing you the most important conference event of the year. With a special focus on the current and future technical developments in tunnelling construction along with a global view of tunnelling activity, the T&T conference promises to fill you in on everything you need to know heading into 2011. The conference will be held at the ICE in London. Contact: email; conference@tunnelsonline.info; tel: +44 (0) 20 7936 6848

3 - 27 OCTOBER 2010
ISRM international Symposium 2010 and 6th Asian Rock Mechanics Symposium, New Delhi, India
Contact: Mr. V. K. Kanjlia, Member Secretary, Indian National Group of ISRM: tel: +91-11-2611 5984/2688 2866/2410 1591; fax: +91-11-2611 6347; email: uday@cbip.org/ cbip@cbip.org; web: www.arms2010.org

6 - 8 OCTOBER 2010
5th International Seminar on Deep and High Stress Mining, Santiago, Chile
Contact person:
Professor Michel Van Sint Jan
Email: deepmining2010@ing.puc.cl
Further information on the website of the seminar:
http://web.ing.puc.cl/~deepmining2010/

9 - 11 NOVEMBER 2010
Harkány 2010 - Tunnel Construction and Civil Engineering Conference
Design and construction experiences from the tunnels on the M6 motorway
Design and construction experiences of the National Radioactive Waste Repository at Bátaapáti
Foresight, the near and the distant future, the vision for tunnel construction and civil engineering
Tel: +36 26 319 368
E-mail: geovil@geovil.hu

23 – 26 NOVEMBER 2010
Bauma China 2010, Shanghai New International Expo Centre, Shanghai, China
The Bauma trade show is famous for it's German event once every three years and the China show is rapidly growing to meet its bigger brother. Contact: Messe Muenchen bauma, China Exhibition Management Messegelaende, 81823 Muenchen, Germany Tel: (+49 89) 949-20251; Fax: (+49 89) 949-20259; Email: info@bauma-china.com

1 - 3 MARCH 2011
International conference and exhibition on tunnelling and trenchless technology at the Grand Dorsett Subang Hotel, Selangor, Malaysia
The 2011 conference orgaised by the Tunnelling & Underground Space Technical Division (TUSTD) at The Institution of Engineers, Malaysia (IEM), will focus on tunnelling in South East Asia, future challenges and management of safety and risk. Contact: Conference Secretariat, Tunnelling and Underground Space Technical Division, The Institution of Engineers, Malaysia Bangunan Ingenieur, Lots 60/62, Jalan 62/4 P.O.Box 223 (Jalan Sultan), 46720 Petaling Jaya, Selangor, Malaysia; Tel: +(603) 7968-4001 / 4002; Fax: +(603) 7957-7678; Email: Tunnel2011@iem.org.my Website: www.iem.org.my

12 - 16 SEPTEMBER 2011
6th International Symposium on Sprayed Concrete, Norway
Sixth International Symposium on the modern use of
wet-mix sprayed concrete for underground support will be held in Tromsø, in the north of Norway.
Contact: Siri Engen The Norwegian Society of Graduate Technical and Scientific Professionals - Tekna;
fax: +47 22 94 75 01

A DATE TO REMEMBER...

If you know of a tunnelling related conference, event, seminar or exhibition that is not listed here, we would be delighted to hear from you. Please contact the editor by post, email, fax or through our web site: Editor, 'Tunnels & Tunnelling International', John Carpenter House, 7 Carmelite Street, London, EC4Y 0BS, United Kingdom.
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BRITISH TUNNELLING SOCIETY

16 SEPTEMBER 2010: **Tunnelling in Seattle - Past, Present and Future**
How tunnels have been used in Seattle and why they are now starting to push the envelope in American tunnelling. The talk will look in detail at recent projects, particularly Brightwater, and at the planned 58ft diameter bore for the Alaskan Way viaduct replacement tunnel.
Brightwater is a $2 billion new wastewater treatment system, which includes 14 miles of soft-ground bored tunnel. Currently under construction, the tunnels are being bored using 2 EPB and 2 slurry TBMs, and are notable for their long drives and high mining pressures. ICE, 5.30pm for 6pm start.

21 OCTOBER 2010: **Sir Alan Muir Wood Memorial Symposium**
The British Tunnelling Society is presenting a symposium on tunnelling and geotechnical themes with papers looking at recent tunnelling case histories, risk, and the inter-relationship of current design and research. Confirmed speakers include, prof Robert Mair, Prof John Burland, Prof David Muir Wood, Robert Muir Wood, prof Paul Jowitt and Martin Knights. Contact: bts@event-logistics.co.uk

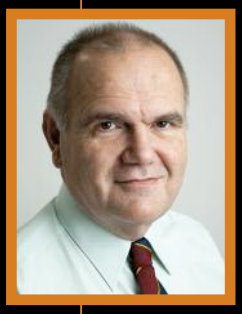
18 NOVEMBER 2010: **Pittsburgh Northshore Connector**
Stephen Woodrow and Andy Miller of Faber Maunsell (AECOM) will deliver this talk on the light rail tunnels in mixed ground conditions with challenging vertical alignment.
The tunnelling works for the Northshore Connector Project in Pittsburgh, USA, involved several engineering challenges. The construction included 6.5m i.d. bore tunnels, 660m long passing under the Allegheny River. ICE, 5.30pm for 6pm start.

16 DECEMBER 2010: **Baggage tunnel design and construction at Heathrow Airport**
Andrew Stephenson of BAA, Enrique Blanco of Ferrovial and Athur Darby of Mott macDonald give details on the challenges of constructing the tunnel under one of the world's busiest airports. ICE, 5.30pm for 6pm start.

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