INTERNATIONAL EDITION
August 2015

Tunnels AND TUNNELLING

\+ Europe

Heath and Safety

Underground Utilities

ROPE ACCESS

Ventilation installation on the Lee Tunnel shaft

LORD OF TUNNELS ABSCONDS

ONE OF THE world's most notorious drug lords has escaped from prison through a tunnel. Joaquin 'El Chapo' Guzman Loera, who is also nicknamed 'The Lord of Tunnels', was being held at Altiplano Federal Prison, claimed to be one of the most secure facilities in Mexico, before absconding on 11 July.

El Chapo's legend has always fed rumours, and this has led to some fresh speculation, so several of the details being reported are suspect. But I will try to put together a picture of what happened last month. That is, assuming the excavation was not staged by Mexican authorities to dupe the United States as some sources are claiming.

On 25 June the US tried to extradite El Chapo, apparently fearing that he was not secure at Altiplano. Unfortunately the once and future escapee was the star prize in the war on drugs, and the Mexican Government was not about to surrender him.

Some 16 days later he was gone. Prison guards then located a 1-mile bore that measured approximately 5ft 7in by 2ft 7in (1.7m by 0.8m) and was accessed via a 30ft (9.1m) deep, 2ft by 2ft (0.6m by 0.6m) shaft.

Oxygen pipes for ventilation as well as electric lighting ran along the entire length of the crown. The tunnel is supported by wooden beams and steel mesh.

Engineers mucked out some 3,250t of earth via a motorbike that ran in one direction, dragging a skip or mine cart that rested on tracks. Early site preparation works involved partial construction of a house near to the prison, which hid mucking activities and also El Chapo's egress, which is thought to also have taken place on the mucking motorbike.

The works are remarkably accurate, and breakthrough into El Chapo's shower block was successful and initially undetected. It has been suggested that the experienced tunnelling division within the Sinaloa Drugs Cartel kept true to the planned alignment with a compass. This is a system that the team is familiar with from decades of constructing smuggling tunnels across the border into the US.

For a cost approximation, various reporters set up a video consultation with a former employee of Pablo Escobar. He estimated construction costs of around USD 50M. El Chapo's fortune of approximately USD 1bn likely financed the project.

The gang has experience of more than 75 known tunnel projects, and is considered a pioneer of sophisticated drug smuggling tunnels. It is thought by US prosecutors that a small, elite crew is responsible for most of the Sinaloa Cartel's work as the work is of such high quality. But the crew has demonstrated that it can also work fast, as US detectives suggested this sort of tunnel would normally take two years, not the 16 months for which El Chapo was incarcerated.

Many of the smuggling tunnels reported in Tunnels and Tunnelling are constructed by this Cartel, which constructed the first cross-border narcotics tunnel in 1989. Their projects are now known as 'super tunnels' to US authorities

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What do you think? Send your views to the editor and join the debate

Alex Conacher
Editor

Cover
Climbing techniques were required to install ventilation in the Lee Tunnel shaft in Great Britain

Next issue
In the next issue of Tunnels and Tunnelling, we focus on the North American tunnelling market for our regional focus. Additionally, we have a special report on 'lessons learned from base tunnels', and a paper on the future of segmental linings

This month...

15 YEARS AGO

The Heathrow Airport tunnel collapse was 'organisational' concluded the Health and Safety Executive report published last month. The 1994 accident was a caving in at three points of partially built NATM underground station tunnels beneath Heathrow's main international terminal. The event, described as one of the worst civil engineering disasters in Britain, led the HSE to declare that tunnellers have a responsibility for safety beyond the norm. Kevin Myers, chief construction inspector for HSE added: "Tunnel projects are frequently beneath urban areas and therefore close to the public. They [...] have the capacity to cause major hazards to ordinary people."
Tunnels and Tunnelling, August 2000, p.7

20 YEARS AGO

A buried nineteenth century sailing ship with a hull of oak sheathed with copper was encountered during construction of San Francisco's MUNI Metro Turnback (MMT). Hydraulic chainsaws were used to cut through the ship and a mechanical cutter was developed to grind the timber. It took approximately 20 days for the shield to advance through the ship's 43ft (13.1m) width. The project is a USD 202M metro extension which includes 840ft of 18ft diameter twin tunnels some 40ft below street level. Driven under 6-12 psi compressed air using an open face shield, the tunnels proceeded with full face breasting and manual excavation through fill on top of Bay mud.
Tunnels and Tunnelling, August 1995, p.6

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Above: Workers equipped with climbing gear install ventilation on a Lee Tunnel shaft

Key people in this issue

DONALD LAMONT
Donald is the animateur of the International Tunnelling Association's Working Group 5: Health and Safety in Works. He is a chartered civil engineer with approximately 40 years experience in the construction industry. He has extensive experience as HM Inspector of Health and Safety, and Head of Tunnel and Ground Engineering for the HSE. In this issue he is interviewed on page 35.

CHRIS DAUM
Chris Daum is president and senior managing director of FMI Corporation and a member of its board of directors. Chris works with public and private companies of all sizes and across multiple sectors of the engineering and construction industry. He appears on page 44.

PETER BISHOP
Peter Bishop is Tunnels Technical Director for Mouchel. A BTS member, and immediate past Chair of the Road Tunnel Operator Association, he was with Mersey Tunnels for 29 years before joining Mouchel and was instrumental in the design and implementation of DDA compliant evacuation safety systems for both tunnels. Read his thoughts on emergency egress for those with reduced mobility on page 30.

STP SAYS TUNNELLING STARTS IN NOVEMBER

USA — Seattle Tunnel Partners (STP) submitted a new schedule to Washington State Department of Transportation (WSDOT), the client announced on July 17, with tunnelling expected to resume in late November. The

Seattle Tunnel Partners began installing a new main bearing on the SR 99 TBM this week. Machine repairs are scheduled to wrap up this fall. STP and manufacturer Hitachi Zosen will then perform an extended series of tests to ensure the machine is ready to complete the tunnel drive.

"Fully disassembling and assessing the machine was always the key to determining how long the repairs would take," said Chris Dixon, STP project manager. "We want to reassemble the machine and resume tunneling as quickly as possible, but we also want to ensure the repairs are done right."

STP crews halted tunneling in December 2013 after the machine overheated. After an investigation, they discovered damage to the seal system and determined it needed to be replaced along with the main bearing.

The cause of the damage has not been determined. Responsibility for costs associated with the delay will be determined through the process outlined in the tunnel contract.

Sandvik announces bumper order

AUSTRALIA — The Lend Lease – Bouygues joint venture has ordered 19 roadheaders for the NorthConnex highway tunnel project in Sydney. Some 13 of these will be supplied by Sandvik, marking the biggest order of tunnel roadheaders for the company since Sochi five years ago.

Models ordered are: six MT720 units, one MT620 and six MT520 units.

The Lend Lease – Bouygues Joint Venture (LLB JV) was formed originally to construct the East West Link project in Melbourne and NorthConnex. The group was the successful bidder on both projects, but following the cancellation of the East West Link project the focus switched to NorthConnex.

The NSW Government, Transurban and the M7 Westlink Shareholders (the Project Sponsors) are in process to build, operate and maintain a tolled motorway linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills – called NorthConnex. When complete, it will link Sydney's north to the Orbital network, and form part of the National Highway route. The scheme includes twin motorway tunnels around nine kilometres in length, with two lanes and a breakdown lane in each direction, as well as an increased height clearance of 5.3m with a speed limit of 80 km/h.

Feds announce funding for new Calgary LRT

CANADA — Federal funding of CAD 1.53bn (USD 1.18bn) will go towards the proposed Green Line in Calgary, Alberta, approximately one-third of the money needed for the CAD 4.6bn (USD 3.55bn) project.

There is potential in two locations for tunnelling work. Transportation engineers are due to submit reports on the alignment in December. Currently there are three options for the line to cross the Bow River: by tunnel, building a new bridge, or attaching a bridge to the lower level of an existing bridge. In the downtown, it is undecided whether the alignment will be at grade, elevated or in a tunnel.

Mayor Naheed Nenshi said he wants construction on the north-south line to begin in 2017, with completion by 2024. The project will double the city's LRT system, adding 40km of track to the existing 59km LRT network. In January 2014, Calgary's City Council approved funding of CAD 520M (USD 401.5M) for the planning, design and construction of the Green Line. According to the city, the Green Line was initially planned to be constructed over 30 years' time, starting as a bus-only Transitway, and later converting to LRT. "This announcement from the Federal Government means that Calgarians in the north and southeast areas of the city will be able to enjoy faster, more reliable, light rail service ahead of schedule."

Skanska selected for Stockholm bypass

SWEDEN — The Swedish Transport Administration has selected Skanska as contractor for constructing the southern connection of Stockholm Bypass tunnel, the construction firm announced July 2.

The contract is worth about SEK 1.3bn (USD 153.9M), which will be included in order bookings for Skanska Sweden for the second quarter of 2015.

The project covers about 350m of tunnel with two lanes in each direction, southbound connections and a new interchange.

Construction work will start in the spring of 2016, with expected completion in 2021. About 150 people will work in the project carried out as a turnkey contract.

LETTER

A few weeks ago I witnessed what was, for me, a tipping point in the street cred of tunnelling engineers. I was enjoying a drink with a group of young tunnellers after the course dinner of the BTS Design and Construction Course at Warwick University. We went to the university bar at about 11pm where there was a bit of a party going on, chiefly involving a large group of rugby union players.

The tunnellers' group was mostly young people and about half were women. The rugby players spotted the latter fact, and joined us for a friendly chat. The conversation went something like this:

"Hi, we're rugby players!" (they said proudly). "What do you do?"

"We're tunnelling engineers" (came the response, equally proudly).

"Wow, women doing tunnelling! We didn't know women did that. Do you know anything about rugby?"

"Not much, we're more interested in tunnelling. We are designing and building some of the biggest projects in the country, and loving it! Do you know anything about tunnelling?"

"Err, no not a lot." (Now looking somewhat perplexed, sensing that the chat-up lines weren't working as planned).

One rugby player then, digging deep in his memory, mentioned something about Bazalgette and the sewer system in London. His friend was stunned by, and became very envious of, his mate's knowledge, and must have inwardly sworn to do some research on the subject in future.

So the group conversation was firmly about tunnels, tunnelling, underground space and technology in general - with the rugby boys struggling to keep up!

A trend for the future maybe? Civil engineering - definitely not boring!

Bill Grose
Director, Bill Grose Consulting

FHWA LAUNCHES NEW TUNNEL INSPECTION

USA — The U.S. Department of Transportation's Federal Highway Administration (FHWA) published the final rule for national tunnel inspection standards that will serve as the foundation of the nation's first standardized tunnel inspection program on July 14. It will be modeled after the FHWA's bridge program established nearly a half-century ago to ensure the safety of the nation's bridges.

"This important step to keep our nation's tunnels safe for the traveling public is unprecedented," said U.S. transportation secretary Anthony Foxx. "Establishing national standards will help us maintain a high level of quality and uniformity in tunnel inspections nationwide."

Up until now, FHWA has provided tunnel inspection guidance but had no means by which to require tunnel owners, such as state departments of transportation or other transportation agencies, to inspect tunnels. In addition, tunnel inspection methods have varied widely. With this new program, FHWA will compile an inventory of the nation's tunnels and begin to develop a national database similar to the National Bridge Inventory (NBI).

The new standards, referred to as National Tunnel Inspection Standards (NTIS), are modeled after the National Bridge Inspection Standards (NBIS) currently used to ensure the inspection of bridges throughout the country. The NTIS include similar inspection requirements and annual reports of tunnel condition information and inspection findings. The requirements will include routine inspections of tunnels on all public roads along with written reports to FHWA, training and a national certification program for tunnel inspectors, and the timely correction of any deficiencies with tunnels.

"Just like bridges, each tunnel is structurally unique and requires dedicated attention and uniform measurement standards," said acting federal highway administrator Gregory Nadeau. "The new Standards will ensure inspections are consistent and focused to help ensure the public's safety."

To support the implementation of the Standards, FHWA has developed several guidance documents and manuals. The agency will offer training to state and local engineers on how to conduct highway tunnel inspections, including on what elements to inspect and how to code and record the results.

Bözberg tunnel contract awarded

SWIZERLAND — Implenia has secured a CHF 145M (USD 151M) contract from Swiss Federal Railways (SBB) for construction of the new Bözberg railway tunnel, the company announced July 16.

In order to further increase the volume of transalpine freight carried by rail rather than road, SBB will upgrade the Gotthard route to a 4m corridor by 2020. This allows even semitrailers with a 4m headroom to be carried.

The project, expected to cost CHF 940m (USD 981m), is an important component of Switzerland's transport policy. In order to create a 4m corridor along the entire length of the Gotthard route, some 20 tunnels need to be enlarged and alterations made to platforms, traction current systems, signalling installations and overpasses.

The largest project within the scheme is the replacement of the existing Bözberg tunnel with a new twin-track tunnel which will allow containers to be transported along the route. Under the project, installation sites are being set up at both locations and the main drilling work will be carried out by a TBM starting at the Schinznach-Dorf site.

Drilling work on the new Bözberg rail tunnel will start at the southern portal near Schinznach-Dorf in mid-2016 and the tunnel is scheduled to become operational in 2020.

Scope of work includes the installation of track and some of the electrical equipment, as well as conversion of the existing twin-track tunnel into a rescue and service tunnel. Both the old and new tunnels will be connected by five cross-shafts to provide emergency access and this conversion work is expected to take place until 2022.

Lee lining complete

GREAT BRITAIN — The contractor has completed the secondary lining on the Lee Tunnel project in London, UK. A joint venture of Morgan Sindall, VINCI Construction Grands Projets and Bachy Soletanche, has completed the secondary lining of Thames Water's 7km sewer tunnel.

A spokesman for the joint venture added: "The innovative secondary lining technique, first developed on the deep shafts of the project, consisted of replacing conventional reinforced concrete with steel fibre reinforced concrete. MVB successfully developed a workable and pumpable concrete mix with Cemex and the newly developed Dramix 5DTM fibre from Bekaert.

Cutterhead arrives in Mexico for Guadalajara light rail

MEXICO — The TBM cutterhead for the tunnel on Guadalajara, Mexico's, Light Rail Line 3 project arrived at the Port of Manzanillo, Colima, on July 18, announced light rail operator Siteur.

Carried by ship from Valencia, Spain, to Mexico, the EPBM has a 11.5m diameter and was manufactured by Herrenknecht Ibérica SA. Trucking the parts to Guadalajara is expected to take about 12 days. Following assembly, it's estimated that testing the TBM could start in September.

Guadalajara-based media reported parts of the TBM underwent rehabilitation in Toledo, Spain, having previously been employed on a TBM drive in Barcelona for a high speed rail tunnel.

The 21km line will have five underground stations and a tunnel some 5.3km long, up to 30m below ground. A consortium lead by Spanish company Sacyr is building the line.

News briefs

INTERNATIONAL

The ITA Committee on Technologies (ITAtech) has published 'draft' guidance for precast fibre reinforced concrete segments. ITAtech writes that "The aim of the document is to present the common understanding of designers, manufacturers and users of fibre reinforced concrete segments of what constitutes good practice in this field of engineering." Although this document is officially a draft, parties involved in its creation have told Tunnels and Tunnelling that it does not detract from the quality of the document, and it can for all intents and purposes be considered a finalised guide. ITAtech advises readers that further information will be available next year when WG 2 (Research) publishes "Twenty Years of FRC Tunnel Segments Practice: Lessons Learnt and Proposed Design Procedure".

Arup director leads BTS Young Member workshop in the Midlands

GREAT BRITAIN — David Twine, director at Arup, has led a contract management and procurement workshop in Birmingham for the BTS Young Members. The workshop, which took place in June this year, was aimed at soon-to-be or newly chartered engineers.

Twine, who is the project director for Arup projects up to GBP 900M has extensive experience managing complex projects.

The workshop provided practical examples and case studies, and also highlighted the importance of material quality and design quality as the economy recovers.

Will Howlett, who coordinated the workshop and is a graduate geotechnical engineer at Arup, said: "The most important point I took down for David's talk is that you should not go for the cheapest option. You can save money in the long term by investing that little bit extra in material quality or design quality. Coming out of a recession it is important to maintain quality in all the designs as cost cutting on projects will cause more financial problems in the future as the designs or material become inadequate in the long term."

Howlett added that this is especially important for the young engineers beginning their careers in a recession.

Howlett said: "They need to ensure that on site quality is controlled and that cost cutting techniques do not affect the end product for the client or end user, who is often the general public."

The workshop was oversubscribed, which highlights the appetite for workshops and talks in the Midlands. Howlett added: "The Midlands is the home of engineering, with current financial restraints of working in London I feel that companies have a lot less overheads when they work outside of the capital," said Howlett. "The reduction in overheads allows more cost effective designs to be passed onto clients. Having just come through a global recession the world is looking for cost effective solutions to all major infrastructure projects. When you have a project worth several million or even billions of pounds if you can save a fraction of a percentage you are in real terms saving a lot of money."

Howlett explained that while another workshop is not yet in the pipeline, the BTS Young Members will plan another event in the near future.

"I will organise another one next year. Having talks and workshops in the centre of the UK allows a lot more people to attend."

BTSYM workshop held at CH2M offices in London

GREAT BRITAIN — The latest BTS Young Members workshop: "An Introduction to BIM" was hosted at the CH2M offices in Hammersmith, West London last month. A lively seminar was led by CH2M's own head of Building Information Moedelling (BIM) development, Vasileios Vernikos. Teams and individual attendees were pitted against each other in challenges to define the benefits and capabilities of BIM, as well as identifying the best ways to introduce and proliferate BIM use within their own companies.

RECORD BREAKING YEAR FOR BTS D&C COURSE

GREAT BRITAIN — Some 88 people attended this year's Tunnel Design and Construction (D&C) Course, in June - July at the University of Warwick. The five day course aims to provide a comprehensive introduction to all aspects of tunnelling.

The course covers all the major aspects of an underground project's life and contains worked examples and workshop sessions to allow improved interaction between delegates and speaker.

The course is aimed at the wide range of professional services that support the tunnelling industry, including clients, tunnel operators and members of the financial and insurance sectors that may have a vested interest in tunnelling enterprises, as well as young tunnel design and construction engineers. And it attempts to give an overview of many of the issues and requirements faced by those working in the tunnelling industry.

As a result, the course is necessarily brief on each subject, but provides a good start for any young engineers or technicians who want to have a career in the tunnelling industry. However, this year a lot more senior people attended the course.

Will Howlett, graduate geotechnical engineer at Arup, said: "A lot of senior/experienced people attended from speaking to people on the course this appears to be because of Crossrail, Crossrail 2, HS2, Thames Tideway all wanting tunnels. So companies are getting their workforce ready for the increase in tunnelling work in the future."

Howlett gave a presentation on the Friday to the delegates. Howlett talked about the BTSYM and how people can get involved. "It is important for the young engineers out there to get involved with their professional bodies.

A break in the programme of lectures on the second day of the course, which covered soft ground tunnelling

Getting involved with the BTSYM is a real way of helping to change the engineering world for the better. Some of the most interesting workshops in the country are free of charge and open to all young members. World technical leaders share their knowledge freely with the young members, which develops them as engineers and increases the knowledge base for the companies they work for."

In 2015, the BTS offered sponsorship for up to five university students or apprentices to attend the course. The sponsorship was open to all students not in full time employement and apprentices, looking for a career in tunnelling. A similar offer is expected to be available next year.

One question asked by many of the attendees was "how can I get a job in tunnelling". The course is perhaps something recruiters should pay attention to in future.

A feature covering this year's course in more detail will be printed later this year.

BLUE PLAINS TUNNELLING COMPLETED

USA — The TBM mining the 4.5-mile-long Blue Plains tunnel completed her dig earlier this month and on Thursday, July 23 her cutterhead was extracted from a 100ft-deep shaft near DC Water's Main Pumping Station in Southeast Washington, DC Water announced yesterday.

"This is a terrific milestone for DC Water's Clean Rivers Project," said DC Water CEO and general manager George S. Hawkins. "We are fortunate that the tunneling went so smoothly, finishing on time and on budget, and I applaud our DC Water staff as well as Traylor Skanska Jay Dee and everyone else who took part in this successful dig."

The JV launched the TBM in July 2013, from a starting point at the Blue Plains Advanced Wastewater Treatment Plant, tunnelling along the Potomac River and crossing under the Anacostia River. Carlton Ray, director of the DC Clean Rivers Project said the TBM performed as well as projected, "having a one-day best mark of 150ft. In her best week, she tunneled 631ft. This TBM's success means we are one step closer to a cleaner Anacostia River."

The Herrenknecht machine built the southernmost segment of the Anacostia River Tunnel. The next section will be mined by another TBM launching at a site near RFK Stadium. The Northeast Boundary Tunnel is the longest portion of tunnel, and that contract has yet to be awarded. At the northern tip of the tunnel system is the First Street Tunnel, a relatively short tunnel.

The Blue Plain TBM removed approximately 1.2 million tons of material that she mined. This was hauled away in nearly 72,000 truckloads over the last two years. She built the tunnel with 28,189 pre-cast concrete segments which made up 4,027 full rings.

Morgan Sindall in Green Apple recognition

INTERNATIONAL — Morgan Sindall has been recognised for its innovative approach to sustainability management – collecting three accolades, including Silver and Bronze, at the Green Apple Awards, an international campaign which recognises and promotes environmental best practice.

Morgan Sindall is one of a select number of companies to be recognised in the annual Green Apple Awards for Commerce and Industry in the area of Environmental Best Practice.

The company was also presented with an Associate Award for its part in Crossrail's Bronze winning entry regarding pollution control as well as recognition as a Green World Ambassador relating to its MVB joint venture. MVB, comprising of Morgan Sindall, VINCI Construction Grands Projets and Bachy Soletanche, which is working on the Lee Tunnel project in London, won an International Green Apple Award 2014 in recognition of their environmental best practice.

The award winners were announced at a ceremony held at the Houses of Parliament earlier this month. The winning entries beat over 500 competitors from across a wide range of sectors including healthcare, estate management, retail, utilities and transport, which demonstrated outstanding commitment to sustainable best practice.

As part of its award applications, Morgan Sindall presented in-depth reports outlining how its project teams manage and promote sustainable best practice across its operations. This included an overall look at the company's core sustainability focus on People, Planet and Profit Total Commitments.

The submissions also highlighted how effective leadership, communication, thought leadership, innovation and legacy, amongst many other aspects, have helped it develop a robust and innovative approach to sustainability management.

John Homer, a regional managing director for Morgan Sindall, chairs the sustainability task-force, actively developing strategy, undertaking reviews and empowering colleagues to deliver.

He said: "We're immensely proud to have won these Green Apple Awards. Our success is testament to Morgan Sindall's unswerving commitment to innovating and developing our processes and approach to sustainability to ensure we are continually improving and moving forward.

"Delivering responsibly is a core component of our culture and touches every aspect of what we do both internally and externally. This ranges from nurturing the next generation of construction talent, setting leading standards in sustainable procurement, and encouraging and enabling our teams to go above and beyond to deliver and conceive truly pioneering delivery and design solutions."

Following the awards, Morgan Sindall is now a Green World Ambassador and will have the chance to represent England in the European Business Awards for the Environment.

Ronnie Leten comments on Atlas Copco's Q2 2015

SWEDEN — Atlas Copco reported solid results for the second quarter, including a record operating profit. The service business continued to grow and the order intake in Europe improved.
The overall demand for the company is expected to increase somewhat in the short term.

"In spite of a generally low level of capital investments, we saw good demand for industrial tools, assembly systems, vacuum solutions and small- and medium-sized compressors," said Ronnie Leten, President and CEO of the Atlas Copco Group. "Our service business is going from strength to strength. We are focusing on creating value for customers while keeping a close eye on efficiency.

Atlas Copco introduced several products in the quarter, including high-performance oil-injected screw compressors, efficient bolt tensioning tools, a speedy surface drill rig for construction applications and small quarries, and an intelligent monitoring system for road construction equipment.

"Innovation is in our DNA, and we are committed to offering break-through solutions that help customers become more productive," Ronnie Leten said.

The Group always strives to create value for customers and deliver higher productivity, smarter ergonomics, enhanced safety and improved energy efficiency.

Tunnel completed for Clare R. Copeland underground power station in Toronto

CANADA — Toronto Hydro announced it has completed a 600m long tunnel, a major milestone in the construction of the Clare R. Copeland Transformer Station, located in downtown Toronto, on June 25.

"Following a complicated excavation project resembling a mining operation, a tunnel connecting the new station to Hydro One equipment has been recently completed," the municipal electricity distributor said in a release.

The tunnel runs 100ft (30.5m) underground from Bremner Boulevard and Rees Street to Front and Simcoe Streets. When construction is complete, electricity will flow through large cables in the tunnel to supply the station.

"The completion of this stage of work is a turning point," said Anthony Haines, president and CEO, Toronto Hydro.

"Copeland Station represents an important piece of Toronto's infrastructure and a smart investment in the grid. It's needed to help power the growth of the city, while respecting public green spaces."

Construction on Copeland Station is ongoing and is expected to be completed in 2016. The CAD 195M (USD 158M) project is the first station to be built in downtown Toronto since the 1950s. This innovative project is only the second underground station to be built in Canada and has been uniquely designed to preserve public green space beside the Roundhouse, a historical building.

TBM launch on Hawaii's longest tunnel, the Kaneohe-Kailua Wastewater Conveyance Tunnel

HAWAII — TBM launch has taken place on the Kaneohe-Kailua Wastewater Conveyance Tunnel in Honolulu, Hawaii. The 3.96m Robbins Main Beam TBM has begun excavation of the 4.6km sewer tunnel. Tunnelling through the local basalt bedrock was kicked off by contactor Southland-Mole joint venture from a 23m-deep launch tunnel, and as Tunnels and Tunnelling went to press, the machine had bored approximately 300m.

A spokesman for the manufacturer said: "During the tunnel design phase, it was decided that the tunnel route should travel inland and deeper underground in order to bypass one of the few residential areas along the alignment.

"Designers introduced an isolated curve in the tunnel alignment of 150m radius, requiring the TBM to be designed with [an unusual] back-up system.

The 3.96m-diameter Main Beam TBM being used to bore Hawaii's longest tunnel

There will also be operational procedures when crews navigate the tunnel curve, requiring the machine to be operated using half strokes rather than a full TBM stroke."

The deep tunnel option was not the first design considered for the project: preliminary plans called for a smaller tunnel travelling under the bay. As Kaneohe Bay is an environmentally-sensitive area, a deep tunnel remained an attractive option.

Richard Harada, of project consultant Wilson Okamoto Corporation, explains the ultimate decision: "A number of factors were considered in making the decision to build a deep tunnel including reliability, construction costs, life cycle costs, environmental impacts, constructability and qualified contractor availability."

Director of Southland Tim Winn added: "There has not been a TBM of this size in the Hawaiian Islands or a tunnel of this length.

The tunnel is being driven from an active Water Treatment Plant (WTP), and space is at a premium. There are also simultaneous contracts being performed there outside the scope of our work."

TBM REMOVED FROM PORT MANN TUNNEL

CANADA — Tunnelling for the new Port Mann water main deep below the Fraser River is now complete, and the joint venture of McNally International and Aecon Constructors removed the TBM on July 17.

The new Port Mann Water Supply Tunnel will more than double the capacity of the existing water main, and help ensure continued reliable delivery of clean, safe drinking water to the municipalities south of the Fraser River. The new main is also designed to withstand a major earthquake.

"The goal of this major infrastructure project is to construct a seismically resistant water main that will not be damaged by river scour, and will meet the needs of future growth in our region," said Metro Vancouver Chair Greg Moore.

"This new water main will replace the existing 40-year-old crossing, which was damaged by river scour.

"This tunnel construction is truly an amazing engineering feat," he added.

The tunnel is approximately 30m below the river bed, and was constructed between two 60m-deep vertical shafts, in which the 80m-long TBM was lowered in February 2014 and removed on July 17.

Now that the tunnel is complete, a new 2.1m-diameter welded steel water main will be installed in the tunnel and shafts, and will connect to the existing water transmission system by means of two new valve chambers, located at the top of each shaft.

Installation of the new water main and construction of the south valve chamber will commence this summer, and the CAD 240M (USD 185M) project is scheduled to be completed in fall 2016.

"This complex crossing of the Fraser River by a tunnel boring machine under very difficult ground conditions is a major technical achievement," said Darrell Mussatto, Chair of Metro Vancouver's Utilities Committee.

The 3.5m-diameter, 1km-long tunnel housing the main crosses between Coquitlam's Maquabeak Park on the north side of the river, and the CN Thornton Yard in Surrey on the south side.

Construction on the Port Mann Water Supply Tunnel project began in 2011.

Left: Seattle Tunnel Partners crews use a milling machine to prepare the surface of the SR 99 tunneling machine's bearing block prior to reassembly. Tunnelling is due to start in November. See story on page 7

GREEK RESURRECTION

Greece's financial woes have undoubtedly had an impact on the country's tunnelling activity, but the sector is resilient and has faced trials before. With many stalled projects under way again, and a few losses incurred to work still in the early phases of planning, things are far from perfect, but there is hope. **Sally Spencer** speaks with local companies and representatives of the Greek Tunnelling Society to get a handle on a tunnelling industry that in recent decades has been marked by extremes

Sally Spencer
Sally joins the Tunnels and Tunnelling team as a contributing editor this year

GREECE'S TUNNELLING sector has been on a rollercoaster ride during the last 25 years, experiencing both dizzying heights and depressing depths as it has tracked the country's economic fortunes.

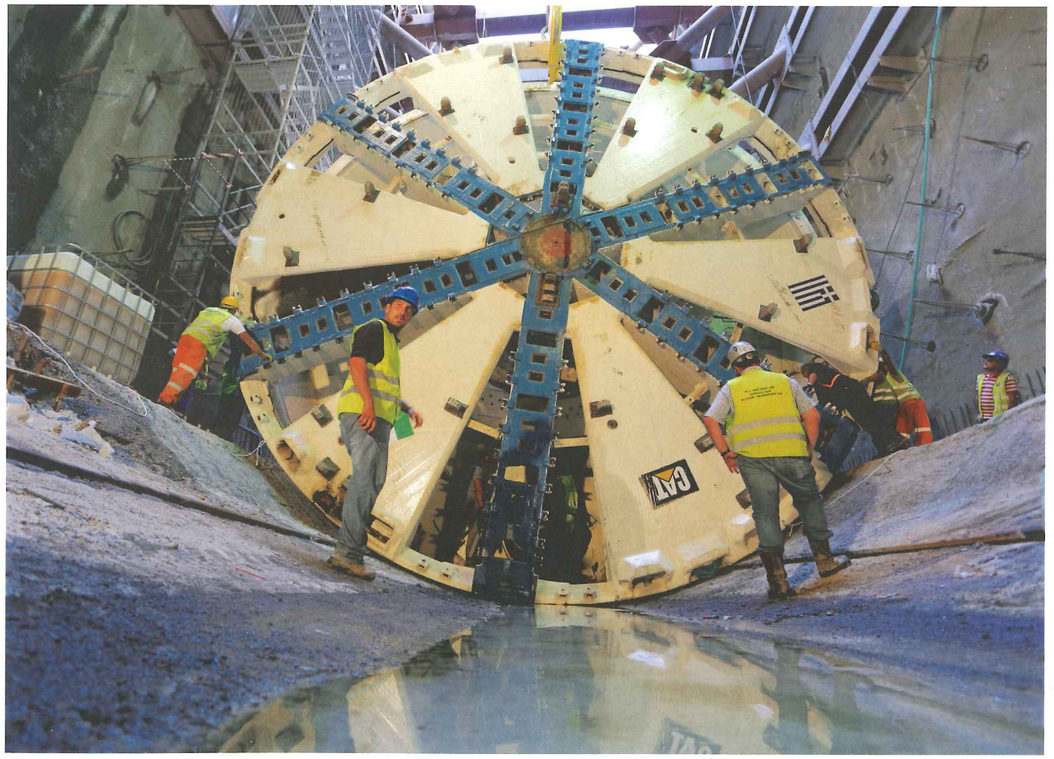
Prior to 1990 there was relatively little tunnelling activity in the country – even Athens didn't have a metro system, for example. From 1990, however, and until the economic crisis began in 2007, hitting Greece really hard at the end of 2009, there was a huge infrastructure boom.

European Union funding, coupled with long-term planning of Greek infrastructure improvements saw tunnels being constructed in road, rail, mining and hydropower projects.

GOLDEN YEARS

These projects included the Egnatia Odos (Roman Road) motorway, which connects the Epirus, Macedonia and Thrace regions in northern Greece and which was one of the largest and most ambitious civil engineering projects in Europe at the time. The road will be a key route in the developing trans-European road network (TERN) and forms an integral part of European route E90. The 670km motorway includes 73 twin bore tunnels with a total single tube length of around 100km and was

Below: CAT EPBM preparing to bore the Athens Metro extension to Pireus



completed by June 2009, on the eve of the financial crisis.

The PATHE (Patras-Athens-Thessaloniki-Evzoni) motorway, which is the main north/south road through Greece, also features "numerous kilometres of tunnelling" along its 550km length.

As does the construction of new high-speed railway lines from Patras to Thessaloniki, again linking north and south.

Another major project, the Attiki Odos (Attica Tollway), forms a 70km ring road around the Athens greater metropolitan area and includes 9km of tunnels.

Greek companies thrived during this period of intense activity.

As an example, leading design company Omikron Kappa Consulting SA (OK) tripled its annual turnover and resources.

"During this time we executed detailed designs of more than 70km in road tunnelling projects, approximately 20km in railway/metro tunnelling projects and approximately 20km in mining/hydraulic tunnelling projects," said Nikolaos Koronakis, OK's president and chief executive officer.

Due to Greece's complicated geotectonic zonation and the fact that most of the projects included ventilation chambers and deep shafts, much of the work was pioneering, he said, which enhanced OK's expertise.

*Above: **Egnatia Odos motorway Tunnel***

*Below: **The EKP Motorway, concession project: Panagopoula T26 twin bore tunnel***

Just three of the many benchmark projects he cites by way of example are the longest highway tunnels in Greece: the 6km Tempi No. 2 twin bore tunnel including cross passages, ventilation chambers and shafts in the Maliakos-Kleidi motorway concession project; and the 4.5km Driskos twin bore tunnel in the Egnatia Odos motorway, which included a 200m deep vertical smoke extraction shaft.

OK also worked on the widest highway tunnels in Greece – the three-lane, plus emergency lane 4.5km Kakia Skala tunnels in the PATHE motorway.

The Human Response

The term "Grexit" is used to describe the potential exit of Greece from the European Union but it could just as easily be applied to the exodus of Greek designers and engineers seeking work abroad.

"In my case my departure from Greece was planned some time before the financial crisis, but it was certainly a catalyst for my leaving," said Ilias Michalis, adding that it was an example of every cloud having a silver lining.

"My co-operation with Deutsch Bahn International started in February 2012 and has given me the opportunity to work for the mega tunnelling Doha Metro project." Michalis is currently tunnel and underground structures manager on the Doha Metro Gold Line.

The regions attracting a Greek workforce include the Gulf, the Balkans, Central Europe, Australasia and China but their departure hasn't left a skills shortage thanks to the boost in the number of trained designers and engineers in the two decades preceding the economic crisis.

"There is still a significant pool of highly experienced and skilled engineers within Greece," said Omikron Kappa's Koronakis.

"The infrastructure boom that began in the 1990s led to the building up of significant human resources with very high training levels, impressive experience and state-of-the-art know-how that are sufficient to undertake the planned projects in Greece despite the sizeable 'brain drain' of Greek engineers and geologists," agreed the GTS's Raptopolous.

And there is belief that as tunnelling activity increases in Greece, some of those expatriated engineers and designers will return to work on home soil, bringing with them "broadened knowledge"

The next generation of civil engineers is also being nurtured.

"In 1998 the Faculties of Mining and Metallurgical Engineering and of Civil Engineering at the NTUA jointly established a postgraduate course for tunnelling, which leads to the postgraduate specialization diploma entitled Design and Construction of Underground Works," said Prof Sofianos.

The course begins each October and comprises two half-year semesters plus a third one for a thesis. The first two terms are devoted to lecture courses and associated activities, while the third is devoted to the preparation and presentation of the diploma dissertation.

Furthermore, a compulsory field trip to tunnels under construction takes place and during this week-long trip students are assigned projects to complete.

"Around 50-60 candidates apply for 20 places on the course each year," said Sofianos, adding that the course is free of fees.

"In addition, there is the possibility for our students to stay at the University facilities, where they can also have meals provided."

PUBLIC PRIVATE PARTNERSHIPS LEAD CONSTRUCTION SURGE

At the core of Greece's surge in infrastructure construction, particularly since 2000, was Public-Private Partnership (PPP) funding.

"In early 2000 the Greek State launched procurement procedures for the construction of five motorways as PPP projects (concessions) with the concessionaires comprising Greek construction companies and European companies from several EU member states," said Ioannis Bakogiannis, a mining engineer and head of the directorate for planning of infrastructure concession projects at the Ministry of Infrastructure, Transport and Networks.

The five motorways are the Olympia Odos (including nine twin bore highway tunnels with a total single tube length of 16km), the Aegean Motorway (including three twin bore highway tunnels, with a total single tube length of 22km), the Ionia Odos (including four twin bore tunnels with a total single tube length of 11km), the E65 (including six twin bore tunnels with a total single tube length of 9km) and the Moreas.

"These are part of the TERN and are considered to be among the most important infrastructure projects in Greece, connecting its regions and playing a decisive role in the country's efforts to overcome the recession," said Bakogiannis, adding that more than 6,000 jobs were expected to be created during their construction.

These concession agreements bundled the design, construction, operation, maintenance and financing phases together and are for a 30-year period, after which they will be returned to the State.

"The PPP model was selected mainly due to restrictions in increasing the country's sovereign debt levels," said Bakogiannis. Furthermore, he added, bundling all the project phases together in one long-term contract rather than spreading them between many parties created a shared acceptance of responsibility.

According to the initial agreements the design, construction, operation and maintenance of the roads during the first phase was to be financed from the public purse in the shape of a State Financial Contribution (SFC) and motorway tolls; and from the private purse in the form of long-term loans and concessionaires' equity.

The loans would be drawn progressively.

Tolls generated through the concession period are considered as public funds and one of the initial effects of the economic crisis when it hit in 2009/2010 was the 40 per cent reduction in traffic volume and subsequent loss of revenue. This, combined with the new credit environment the Greek government found itself in resulted in the lending banks retrenching.

"The Greek PPP projects were inextricably connected to the banking system, whereas the government-funded projects were mostly being financed by secured European funding schemes," said Koronakis.

"The lenders were very sceptical about

*Below: **Completed Athens Metro Station***

the ability of the Greek government to meet all its contractual commitments for State financial contributions and other financial needs of the projects," said Bakogiannis.

Doubting the long-term viability of the projects, the banks suspended the drawdown payments for four of the concession projects – Olympia Odos, Aegean Motorway, Ionia Odos and E65 – resulting in the suspension of construction from spring 2011.

The Moreas was sufficiently well advanced to escape the suspension.

INFRASTRUCTURE RESTRUCTURE

However, while work was severely delayed, no projects that were already under construction at the end of 2009 were abandoned, although significant delays were recorded. After a two-and-a-half year hiatus, in December 2013 the four concession contracts were restructured and work re-commenced. The roads should now be completed by the end of 2016.

"The restructuring was agreed on the basis of a new fiscal balance model, mainly in the form of substantial State financial contribution and a recycling mechanism of toll revenues," said Stavros Raptopoulos, president of the Greek Tunnelling Society.

"In essence the State has taken up all the contractual risks, acting more as a last resort funder than as a partner in a PPP."

He added that re-starting the concession projects didn't involve any re-costing per se. Instead, some sections of the initial scope of works were dropped and will be constructed as conventional public procurement works.

"As for designs, no ad hoc amendments were made in order to reduce costs," said Raptopoulos.

"Some changes did occur, but not directly linked with the present fiscal crisis in Greece. For example, final linings are conventionally constructed in Greece using reinforced concrete. Before the current crisis, and due to the high cost of steel, some contractors had proposed the adoption of unreinforced concrete final linings in some instances (road tunnels or rail freight tunnels in competent rock and enough overburden cover)."

"Re-negotiations did not involve re-evaluation of tunnels' designs given the fact that the designs were generally considered to be as optimum as possible and fit for purpose," added Koronakis.

In practice only the concession projects have been renegotiated and, according to Bakogiannis, there is still profit to be had – and this will increase in the case of economic recovery and an increase in traffic loads.

There has been some company-specific impact, of course. For example, prior to the crisis, Geodata Greece, the Greek arm of Geodata Engineering was involved in three major tunnelling projects: the detailed design of the Klokova twin road tunnel (about 3km), which is part of the Ionia Odos motorway; the detailed design of the Agios Georgios twin road tunnel (about 410m) in the Patra-Pyrgos motorway; and the detailed design of Line 3 of the Athens metro extension to Pireus (double track single EPB/TBM driven tunnel of about 6.5km).

When the economic crisis hit, only the Athens metro project continued smoothly.

The Greek debt crisis

The financial spotlight fell on Greece with the onset of the global economic meltdown in 2008.

National spending had increased to alarming levels but this only became apparent to Greece's European Union counterparts when it announced in October 2009 that it had been understating its deficit figures for years. As a member of the EU, Greece was required to prevent its national budget deficit exceeding three per cent of its economic output. Greece continued to report a national deficit of 3.4 per cent while in reality that figure was more than 15 per cent.

Financial markets closed their doors to Greek borrowing but with the country heading towards bankruptcy by the spring of 2010, the so-called troika of the International Monetary Fund, the European Central Bank and the European Commission issued the first of two international bailouts for Greece. These bailouts totaled EUR 240bn (USD 264bn).

The conditions attached to the bailouts called for harsh austerity measures, budget cuts and sharp tax increases. The measures have hit the country hard – unemployment is now more than 25 per cent and the economy has shrunk by 25 per cent since 2010.

The Greek economy became even more volatile with the election this year of the anti-austerity Syriza party, which is now at loggerheads with the rest of the EU, particularly Germany, which is frustrated by Greece's apparent inability to carry out the required economic overhaul.

There are fears that if Greece were to default on its loans and exit the Eurozone, the shockwaves could be felt further afield, impeding many recovering, but fragile, economies.

As Tunnels and Tunnelling goes to press a possible third bailout has been negotiated, and short-term financing agreed. This has allowed the banks to re-open following their hiatus, but fears of Greece crashing out of the Eurozone are still strong, and the bailout has been widely criticised.

***Below:** The Kakia Skala Tunnels on the Pathe Motorway*

***Above:** The Albania Krrabe Tunnel on the Elbaban Motorway*

***Below:** A mining project worked on by Omikron Kappa Consulting*

"The first two projects were put on hold," said Nikolaos Kazilis, Geodata Greece branch manager.

"The Klokova project then continued but the design was awarded to a different company [on cost grounds] and the Agios Georgios project was cancelled."

EARLY STAGES PROJECT CULL

Perhaps the most far-reaching impact of the current financial maelstrom will be felt in the future as many projects that were in the early stages of planning have been postponed.

"There was an unparalleled cutback in new business developments in terms of launching new forthcoming tenders," said OK's Koronakis.

"Many designers were driven to offer unacceptably low design tenders in order to maintain a piece of the pie and occupy themselves at any cost," he said, adding that OK had made the decision not to adopt this strategy.

"We decided that under no circumstances would we consider cutting back on the quality, reliability and fit-for-purpose value of our designs and services," he said.

According to the GTS's Raptopolous, postponed tenders include Athens Metro Line 4, a state-of-the-art EUR 3.3bn (USD 3.65bn), 32km-long project destined to "dramatically upgrade the transportation system of Athens".

"The crisis brought about considerations for partial tendering of the project in five phases, A to E. A number of financing scenarios are under examination in order to create funding leverage using extra sources other than national or EU ones," said Raptopolous.

He added that the procurement of three new concession projects has been postponed: the 1.1km-long immersed tube road tunnel link from Salamis Island to Perama; the 1km-long immersed tube road tunnel link for Lefkas Island; and a new Elefsina-Thiva-Yliki motorway, bypassing Athens.

A number of rail projects, incorporating tunnels, had been severely delayed but are now back on track.

"Excavation and final lining at the 9km-long single track twin tube Kallidromo rail tunnel have been completed and the remaining civil and E/M works are in progress," said the Ministry of Infrastructure, Transport and Network's Bakogiannis.

"Also under way is the construction of the 5km-long single track twin bore rail tunnel in Panagopoula; and along the Lianokladi-Domokos rail section three small double track tunnels with a total length of 1.62km and the 6.4km-

long single track twin bore tunnel of Mount Orthrys (including one 1km-long access tunnel) are under construction and 10 double track small tunnels and cut-and-covers are completed.

"Procurement of another section, including some rail tunnels, was announced at the end of March," added Bakogiannis.

"Over the last year some Greek PPP projects have been given the green light and are slowly but steadily being re-activated," said Koronakis. Among those that OK is involved in are the Maliakos-Kleidi (MK) motorway concession project and the Elefsina-Korinthos-Patras (EKP) motorway project.

"Both projects include the completion of a series of road tunnels with significant length," said Koronakis. "Tunnels Tempi No.1, Tempi No. 2 and Platamonas of the MK motorway total about 22km and the Panagopoula tunnels complex and Platanos tunnel of the EKP motorway total about 12km."

GREEK HOPES FOR THE FUTURE

Looking to the future, there is hope and expectation that many more projects will go ahead.

"I strongly believe that infrastructure projects always have a boosting effect on any economy, especially during periods of recession," said Ilias Michalis, a Greek engineer now working for Deutsch Bahn International on the Doha Metro Gold Line (see boxed text).

"That has always been the case since the 1950s. The Greek construction industry suffered major disruptions in the 1980s and 1990s but it managed to recover.

"Now the situation isn't easy and new contract schemes must be used between the Greek State and the private sector," said Michalis. "These contracts must be focused on the development of existing infrastructures such as the airports and main ports at Greece's tourist destinations as I believe the tourist industry is the main pillar on which growth in the economy of Greece can be based."

Metros and motorways are high on the wish lists of other key players.

"I believe the main motorway concessions will go ahead with some modifications in their investment schedules," said Geodata's Kazilis. "And I think some metro jobs, both in Athens and Thessaloniki will proceed as the demand is always there and some of the funding has been secured."

"I would like to see the Metro projects for Thessaloniki, Athens and some other large cities, such as Patras, go ahead," added Professor Alexandros Sofianos, director of the design and construction of underground works postgraduate course at the Department of Mining and Metallurgy within the National Technical University of Athens (NTUA).

"Trenchless technology related to sewerage renovation and water outfall have a high potential, although little has been done yet," he added.

"Some immersed tubes should also be considered, such as for the Salamina strait crossing."

Along with Athens' and Thessaloniki's metro systems, Omikron Kappa would also like to see the construction of new high-speed railway lines in the mainland; the construction of new roadway stretches in the provincial road network, or in existing by-passes; the construction and/or modernisation of airports and ports and their connections to road and rail axes; and dam construction and affiliated civil works relevant to water supply and irrigation schemes.

"These are sectors that could and should be improved in order for the country to be able to rise to the future demands," said Koronakis.

Short to medium-term aspirations for the Greek Tunnelling Society include the aforementioned Athens and Thessaloniki Metro systems and the completion of the "BOAK" (Crete's north road axis), where only 41km of the total 310km have been constructed.

"It's crucial to complete this motorway, which is part of the Trans-European Transport Network," said Raptopolous.

He also cites the completion of the high-speed railway network from the west cost city of Patras to the Greek borders with FYROM, Bulgaria and Turkey and the linking to the EU and international rail network.

Others on the agenda are the construction, through a Concession scheme, of the "Castelli" international airport at Herakleion, Crete; various projects in the field of fluid and solid waste management and water resource management including small dams.

And importantly the construction of the Trans-Adriatic Pipeline and the so-called "Turkish Stream" natural gas pipelines and expansion of the natural gas local network.

VARYING CONFIDENCE

Confidence and optimism levels differ depending on personal perspectives but there is a consensus that the Greek tunnelling sector will survive and, ultimately, prosper.

"Tunnelling projects will still have potential in Greece for a number of years because it's not just a matter of choice, it's a matter of need," said one contact.

"The construction sector must emerge stronger and with a different orientation," said Michalis.

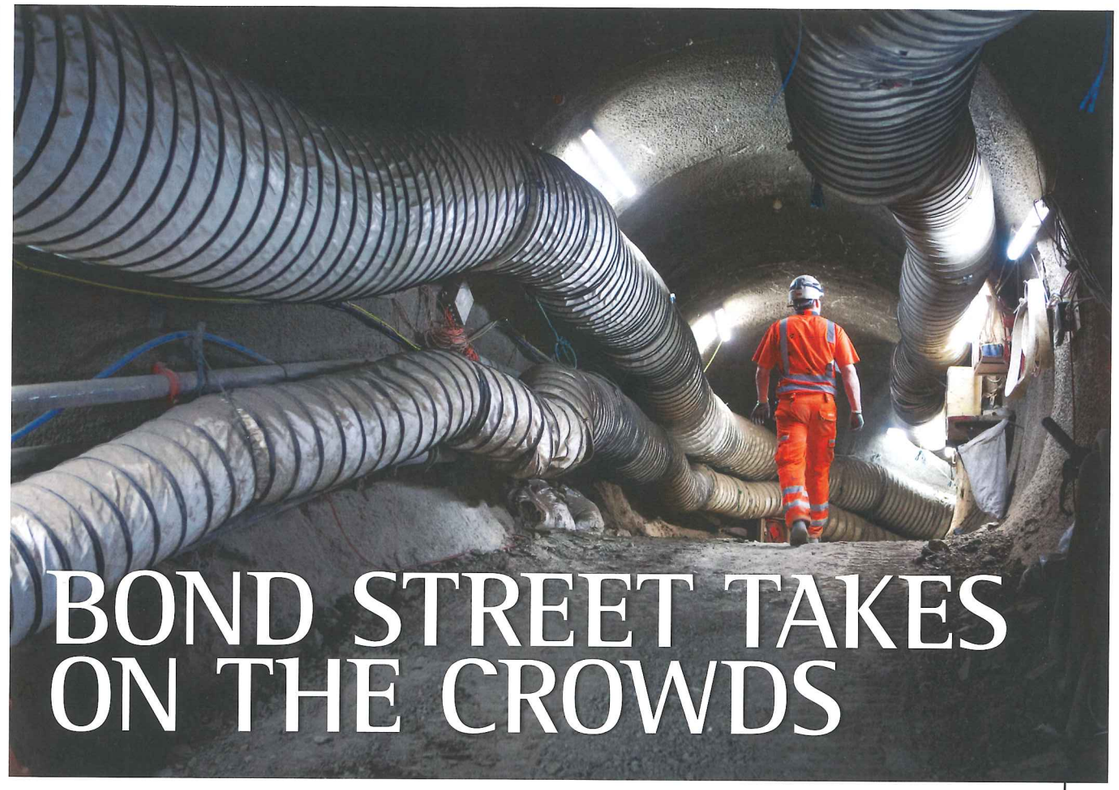
"Some restructuring has already taken place and, in addition, the Greek construction sector has shown a significant extroversion, mainly in the areas of the Balkans and the Middle East," he added.

"These experiences will be extremely useful: they can provide the necessary financial means to the main Greek construction companies.

"And they can create confidence within those companies and their international competitors that co-operation is possible and can be beneficial under the current conditions of strong competition in the world construction sector"

Tunnels and Tunnelling would like to thank Petros Fortsakis for his advice and assistance with this article

Editor: The bulk of this article was researched and written early in the summer of 2015. The Greek situation being as fluid as it is, the status of some of these projects may change



BOND STREET TAKES ON THE CROWDS

A GBP 320M (USD 490M) upgrade of Bond Street London Underground station will add much needed capacity prior to Crossrail's arrival in 2018. **Sally Spencer** reports

Sally Spencer
Sally joins the Tunnels and Tunnelling team as a contributing editor this year

LONDON'S WEST End is no place to be if you have an issue with crowds. Oxford Street in particular is a place of rush and tear where crossing the pavement, let alone the road can be hazardous.

And it's a scene that is mirrored underground, where hundreds of thousands of travellers make their way through the capital's complex Tube system every day.

Bond Street station, currently accessed from the south side of Oxford Street, is a case in point. Built in 1900, no-one at the time could have anticipated that today it would be catering for 175,000 Central line and Jubilee line passengers a day – a figure that is increasing all the time and that will jump to more than 225,000 a day when Crossrail arrives at the station in 2018.

The arrival of Crossrail may have provided a catalyst for the GBP 320M (USD 490M) redevelopment of the station, but the reality is that Transport for London (TfL) and London Underground (LU) have been committed to upgrading the Tube system for many years and the Bond Street Station Upgrade (BSSU) is one of many on the agenda.

"It's often thought that when we're carrying out improvements on the network we're just 'fixing the Tube'," says Miles Ashley, LU's Programme Director of Crossrail and Stations.

"It's actually part of the continuity we need to keep our heads above water with the enormous growth we have in London.

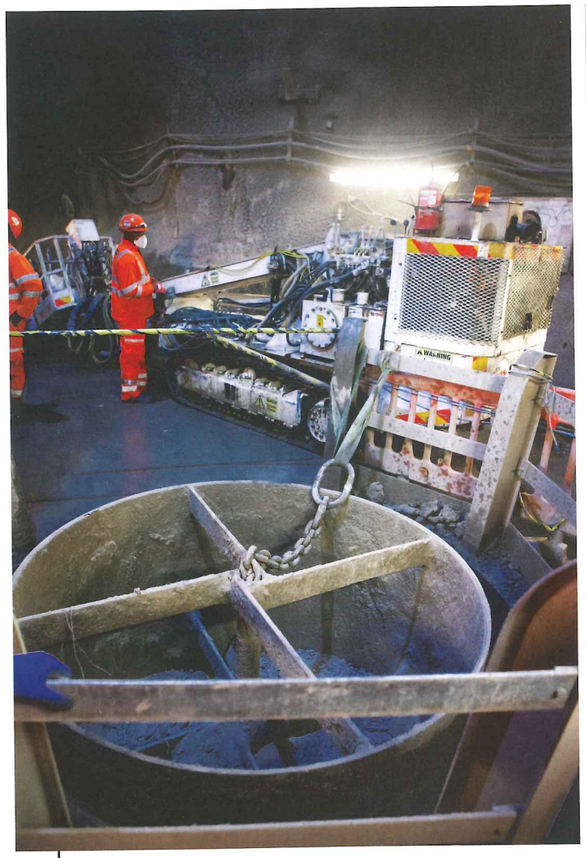
"The number of passengers we carry has doubled every 35 years since 1863. Now we're facing the prospect of an increase in London's population from 8.5 million today to 10 million by 2030. That equates to another Tube train full of people every three days.

***Above:** Crossrail construction adit. This tunnel is only for temporary access and will be filled once all the tunnelling excavation is complete*

"The BSSU is a result of that growth – during the last seven years there has been an almost 50 per cent increase in the number of passengers using the station. Crossrail will add another 30 per cent on top of that." Approximately 50 per cent of the passengers using Bond Street do so to interchange between lines and never reach the surface.

CRITICAL PATH

He added that there's no point in investing in more and faster trains if the passengers can't be cleared from



the platforms in time.

"The Jubilee Line is one of the most frequent train services in Europe at up to 36 trains per hour, but it's no good if you can't get people off the platform before the next one comes along."

In a nutshell the BSSU project, which is being delivered by the Costain-Laing O'Rourke joint venture, will increase capacity by 30 per cent; new pedestrian tunnels, a new ticket hall and escalators will offer increased access to the Jubilee and Central lines.

Greater "permeability" to the Jubilee Line will create a more even distribution of passengers along the platform and, therefore, through the trains, and improve the flow of passengers in and out of the station.

The project also features an improved interchange between Central and Jubilee lines and access to the new Crossrail station (which will have its own entrances at nearby Davies Street and Hanover Square).

The BSSU also features a new station entrance and ticket hall on Marylebone Lane, on the north side of Oxford Street. In addition to the eight existing escalators in the station, two escalators within the new tunnels serving the Jubilee Line and four new lifts will deliver step-free access to all platforms for the first time – LU plans for more than half of rail and Underground stations to be step-free by 2018.

The project is due for completion and full operation in 2017 and has entered the final stages of tunnel construction. More than 500m of tunnels have now been excavated beneath Oxford Street, plus the basement-level ticket hall.

The works include two approximately 10m-diameter access shafts. The base of Shaft 1 is 28m below street level while Shaft 3 is 18m below street level.

A lift installed in Shaft One will take passengers down from the ticket hall to the interchange level where they can access the Jubilee and Central lines and Crossrail. This shaft will also have an emergency escape staircase and will house various services.

Another lift has its own sprayed concrete lined shaft connecting with the Jubilee and Crossrail platforms. There are two other lifts, one in square works giving access to the Central line and one in reinforced concrete at basement level providing access from street level.

The works also feature two construction adits, two binocular cross passage tunnels, two large concourse and connection chambers, three underpass tunnels, three over-bridge tunnels cutting through the cast iron segments of existing platform tunnels, two niches for electrical and mechanical equipment and one inclined tunnel for escalators. Tunnel widths range from 4m-10.2m (external).

CRAMPED CONDITIONS

Perhaps the biggest challenge for the project is that it has been taking place within a very tight space – the only available footprint within Oxford Street is just 330m2.

One space-gaining strategy has been to construct a five-storey concrete and steel-reinforced frame building, replacing a bank that had stood on the site of No 1 Stratford Place, until LU bought and demolished it as part of the BSSU programme.

Only the frame of this over site development (OSD) building has been constructed above ground level, together with two levels of RC basement.

The top three floors currently house site offices, workshops, welfare, showers, laundry facilities and so on. Plant is housed on the roof, including large ventilation fans that force air into the tunnel works.

"We're bringing in the freshest air we can find, well away from the Oxford Street traffic and pumping it through big ducts down into the works," said Richard Watts, LU Tunnels project manager.

The lower two 'basement' storeys encase the access, via two shafts, to the works below.

Spoil is also extracted from this point, leaving via Marylebone Lane. Again, the tight access has created immense challenges, with spoil removal organised on the basis of one lorry out, one lorry in, with up to 14 lorries leaving the site each day, each carrying 18.5t of London clay.

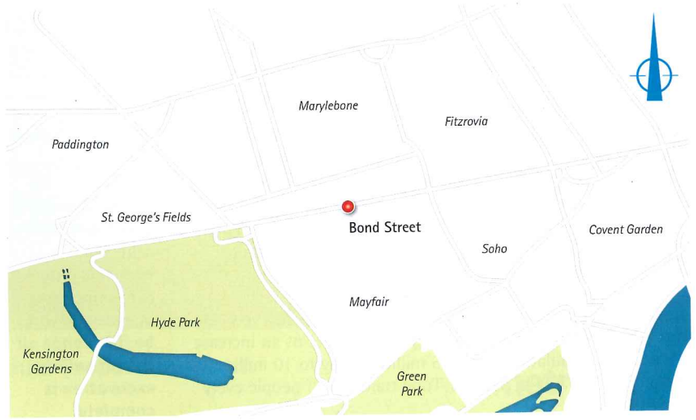
"At one time we were running three tunnel drives and two shafts through this one entry point, effectively running all the logistics in to a cul-de-sac," said Kevin McManus, Tunnel Construction Manager.

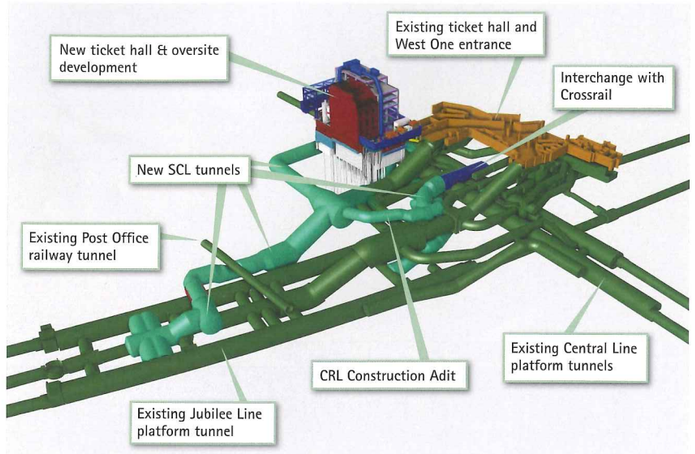
Acoustic cladding swathing the building has ensured the residents of a neighbouring five-star hotel haven't been disturbed by the 24/7 tunnelling operations (there is no spoil removal at night).

Of course, the ground beneath Oxford Street is also already pretty crowded and as well as synchronising with the Central and Jubilee lines (which, critically, have remained operational) and Crossrail, the BSSU project has had to contend with ducking under the mothballed – but much revered – Royal Mail underground railway line and avoiding the equally iconic and somewhat more

*Above: **Engineers working in a confined environment***

*Below: **Location of Bond Street within Central London***





*Above: **Computer generated model of underground structures at the station***

*Below: **Digging the new SCL tunnel leading to the Jubilee line platforms viewed from the new lift shaft***

The BSSU project team

Main contractor: Costain Laing O'Rourke, working as One Team, with London Underground
Designer: Halcrow/Atkins
Sub-contractors: Dr Sauer (SCL design); Joseph Gallagher (tunnel construction); VVB (M&E tunnel support); Bachy (compensation grouting); Wessex (steel work for temporary and permanent works); Alan Auld & Donaldson (temporary works design); Expanded (demolition of 1 Stratford Place); Explore (pre-cast concrete OSD structure); Otis (escalators and lifts)

sensitive Bazalgette-designed Victorian sewer system and water mains. The Costain-Laing O'Rourke JV contractors protected 1.2km of the fragile cast iron pipes of the latter by installing plastic strengthening sleeves.

There have also been the sensitivities of the sovereign territory of two High Commissions to overcome – those of Botswana and Tanzania. Based at 3 Stratford Place, the latter is an immediate neighbour to the development site, which occupies 1 and 2 Stratford Place. Number 1 is now the OSD building, while the basement of number 2 (a Grade II-listed building bought by LU at the beginning of the upgrade process) has been excavated over a period of 18 months and a concrete box constructed, and is being transformed into the new ticket hall – all without disturbing the building above. This basement adjoins the High Commission's visa application office.

As the ground beneath the High Commission is technically Tanzanian soil, and the enabling legislation of the Crossrail Act doesn't apply to Tanzania, the BSSU team had to design a solution to go around, rather than through it. So now, an access tunnel, built to get the spoil out and the materials in to enable the escalator shaft to be driven down to the Jubilee Line, heads out parallel with Stratford Place for 35m before taking a right angle turn back under the development site.

The team is phlegmatic about the task of threading new tunnels through existing utilities and stakeholder interests.

"It's just part of the challenge of working in these very tight urban environments," said Ashley. "On a job like this you are probably trying to maintain relationships with upwards of 300 individual stakeholders, protecting their interests as well as creating additional capacity and keeping the Tube moving."

And, he added, dialogue pays. "If we weren't as careful with those relationships people could object and constrain us in ways that would be very sub-optimal but, generally, once we've worked with them there is a level of understanding that allows us to get the most efficient outcomes."

AIM SMALL, MISS SMALL

Noise and dust pollution levels have been meticulously monitored, as has ground settlement, which has been mitigated by compensation grouting.

"Worst case scenario, if we'd just dug our tunnels and done nothing we would have had up to 70mm settlement in the middle [of the project area]," said Watts. "The fact is that the team has built the tunnels very carefully, combined with the compensation grouting has resulted in much lower figures than that.

"Ninety-three Tube a Manchette's (TaMs) were drilled in a roughly 180 degree arc from just in front of 2 Stratford Place and picking up all the main buildings," said Watts.

Design decisions

Close coordination between designers, constructors and client has been key to successful implementation of the project, according to lead designer Halcrow Atkins JV. A spokesman for the team says that it co-located its design team with the Costain Laing O'Rourke (CoLOR) JV and LU to aid collaboration, and that use of a detailed 3D BIM model has also ensured cross-disciplinary coordination.

Tunnels and Tunnelling speaks with Mike Sleath, tunnelling design team leader for Atkins, to get a better idea of some of the design challenges.

"Challenges within the tunnelling design included: Severe constraints on geometry requiring a variety of tunnelling techniques and structural forms; large SCL caverns directly under compensation grouting TAMs; numerous adjacent structures highly sensitive to settlement, including Grade-listed buildings, sewers, the Post Office Tunnel and LU assets including escalator chambers and track; and numerous tunnelled connections to LU tunnels requiring design to minimise impact of the operational station," says Sleath.

"We had to create extra spaces all over. There are a host of structures squeezed in between existing tunnels. For example, stairs needed to be squeezed in between the Central Line platforms. This called for the use of square works – steel columns and beams – to construct as the space was too tight to construct an SCL arch. While at the northern end of the Jubilee Line platforms, a large cross passage tunnel connecting a staircase to both platforms was constrained by structures and passenger flow requirements. This overly large structure was re-engineered with Dr. Sauer & Partners as a binocular tunnel, that is one with a central wall and passengers either side."

Sleath also points to the challenge of working adjacent to station structures for which archived engineering records are of variable quality. The Jubilee line, opened in 1979, had generally good records. However records for the Central line, opened in 1900, are much less accurate. "Issues such as these have meant that the placing of a "Resident Engineer Equivalent" (REE) in the construction team has been of great value to the project. The role is to ensure ongoing design support during construction, and allows small changes to the design to be made quickly on site, without waiting on action from the designer's office."

In some cases the complex project schedule threw opportunities for optimisation at the teams. For example, the Lift 3 shaft was originally designed to be constructed top-down, but due to advances on other parts of the project, excavating from the mid-level turned out to be the preferred solution, and saw some weeks of time saving.

There were quite a lot of areas we couldn't get into because of existing basements, foundations, piles and so on, but the operation was very successful and was demobilised just after Easter.

"We have monitoring on the whole of Stratford Place and a number of other buildings around the area and the biggest movement we've had is 25mm."

Conventional 360 excavators have carried out most of the BSSU tunnelling work, including the escalator shaft – with roadheaders being used in some of the larger areas such as the construction adit.

The very close proximity to existing infrastructure and assets in certain locations, such as the connection with the Central Line, between the two Central Line tube tunnels has necessitated another conventional technique – steel framed square works.

In these areas the new tunnels are squeezed between the existing tunnels, which are exposed on both sides.

***Above:** Access to station projects in central London is constrained*

"Where we went under the Central line we could hear the trains running above us so we had to keep a very close eye on the track and we virtually didn't disturb it at all," said Watts.

"In two locations the tunnellers exposed the underside of the SGI running tunnels while the trains continued to run above."

All of the square works were dug by hand and, due to space restrictions all of the passageways between the two Central line platforms connecting to the future lift were excavated this way.

SCL VANGUARD

However, not all the techniques employed date back to the earliest days of tunnelling and sprayed concrete lining

(SCL), brings the BSSU project bang up to date.

The SCL is reinforced with 38mm steel fibres and is sprayed on in one metre advances to a thickness of around 250mm tor form the primary lining, which provides temporary support for the tunnels. A sprayed waterproof membrane is then applied before the final structural lining, using the same fibre-reinforced concrete mix.

The concrete is supplied in bulk in containers and the site has storage capacity of 250t – which sees a rapid turnover.

"We had an 80m³ pour at the weekend and by Monday we were down to 50t," said Watts.

"SCL has also proved to be a very low ground movement technique and that should give confidence not only to designers, but to stakeholders in the future," said McManus.

LU has been at the vanguard of SCL use in London. Ashley added, "These are amongst the first jobs where SCL has been used on London Underground, and they have been a forerunner for the Crossrail works.

Essentially we are building data through using this technique that will give stakeholders on future projects confidence that their buildings aren't going to suffer."

Above: Specialist plant for forming the SCL tunnels shown in the interchange passages

SCHEDULE

Primary excavation of the tunnels was completed in July and construction of the secondary lining is now proceeding. Fit out is scheduled to begin this September.

The much anticipated tunnel breakthrough connecting Bond Street and Crossrail is due to take place in late September 2015.

"Crossrail has completed the excavation of its tunnel linking their station with ours and we're in the process of digging back the other way to join it, tunnelling over the Central line in the process," said Watts.

"The final link is S-shaped and will be built in SGl. It is a very complicated section, mainly because of the Central line overbridges and the sewer, which is 500mm above them.

"The work is very slow and laborious and it will take us until September to complete it."

A JOB WELL DONE

The BSSU team's pride in this cramped and complex project is evident and its accomplishments are being recognised by the wider world. LU has become the first rail authority in Europe to achieve ISO 55001, the new international standard for asset management.

These LU schemes are providing close to the best return for peak hour capacity anywhere in the world," said Ashley. "The way we approach them, and apply sophisticated modelling, such as Legion modelling, gives us much more understanding of how to optimise these environments.

"Several other metro projects are very interested in how we employ that modelling to get the best out of the operation and the infrastructure we're building"

EMERGENCY EGRESS WITH REDUCED MOBILITY

Peter Bishop, technical director for tunnels engineering at *Mouchel* raises the issue of providing for the needs of those with reduced mobility during a road tunnel evacuation

Peter Bishop
Peter is the tunnels technical director for Mouchel, based in Liverpool

TO FIND oneself in an emergency situation, having to evacuate from an unfamiliar building, or environment, is stressful enough for any able-bodied person, but when suffering from reduced mobility, that sense of foreboding is greatly accentuated.

When an evacuation involves a potentially smoke-filled tunnel and you have difficulty walking, seeing or perhaps even hearing, it adds a whole new dimension to the situation. Indeed, even without those concerns, many people find travel through a tunnel an already unpleasant and unnerving experience.

The World Health Organisation calculates that at least 15 per cent of the world's population have some form of physical disability or other impairment. That percentage equates to over a billion people, with 80 per cent of them living in developing countries. In the UK alone, there are 11 million people registered as "Disabled", 4.6 million of whom have walking difficulties with 800,000 wheelchair users. There are also half a million "Motability" adapted vehicles on UK roads.

However, the term "reduced mobility" embraces many more individuals and groups who might experience difficulty in evacuating a tunnel to a place of safety during an emergency. Approximately 20 per cent of the population in the European Union (EU) is over 60 and many find walking any distance, or climbing stairs, extremely arduous due to degenerative diseases like arthritis, osteoporosis, heart, lung, knee and hip problems.

Equally, one could make a reduced mobility argument for the morbidly obese, a pregnant woman, or a young mother travelling alone with two or three small infants. Her walking speed to reach a place of safety would be determined by the pace of the slowest infant or the degree of difficulty with which she could carry the youngest.

Add to that those who may be physically capable of self-rescue but become paralysed by fear and find themselves unable, or unwilling, to evacuate the perceived "safety" of their vehicle plus those who suffer from severe visual or hearing impairment, and it is conceivable that one in every six persons involved in an incident requiring evacuation might find difficulty self-rescuing to a place of safety if they have to climb up onto an elevated walkway, use a staircase, or walk up to 250m, perhaps on a steep gradient, to reach an exit.

In 1995 the UK, through the Disabilities Discriminations Act (DDA), made it unlawful to discriminate against people in respect of their disabilities in relation to employment, the provision of goods and services, education and transport. In general, UK designers have made efforts to comply within reason, however that is not always the case elsewhere.

When the DDA was replaced by the Equality Act in 2010, the type and scale of any 'reasonable adjustments' a service provider was required to make to ensure people with disabilities could overcome "any substantial disadvantage" posed by the service providers operation was far more prescriptive, with mention of ramps, stairway lifts, wider and automated doors together with better lighting and clearer signage.

Below: The Kingsway Tunnel is due to undergo upgrade works

In tandem with UK legislation, the United Nations (UN) published a Convention on the Rights of Persons with Disabilities, which all members signed up to in 2006. It called for reasonable accommodation by modifying existing infrastructure without imposing a disproportionate cost, for the first time alluding to the notion that disability provision should be considered when designing "new infrastructure". The wording of two articles has particular relevance for tunnel designers and operators, whether for road or rail usage.

Above: Hatfield Tunnel pre-renovation showing elevated walkways

UN ARTICLE 9 – ACCESSIBILITY

"Access on an equal basis to the physical environment, of transportation by the elimination of obstacles and barriers to accessibility, these to include buildings, roads, public transport, and other indoor and outdoor facilities."

UN ARTICLE 11 – SITUATIONS OF RISK AND HUMANITARIAN EMERGENCIES

"All necessary measures shall be taken to ensure the protection of persons with disabilities in situations of risk."

Furthermore, the EU Charter of Fundamental Rights outlaws discrimination on the basis of disability with the EU Directive 2004/54/EC on Road Tunnels stating that, "the needs of the disabled should receive particular consideration during all design processes", stopping short of specifying "step free" escape routes.

Eminent investigative psychologist Professor David Canter maintains that the common notion of panic during emergency situations is not strictly true and that most fire evacuations are actually quite orderly, noting that in crisis situations one or more leaders often emerge from the affected group to help the young, old and infirm, reach an exit – often putting themselves at risk. A tunnel designer or operator however cannot, and should not, rely upon that

More to come

A number of operational and technically innovative solutions to the issues raised in this article will be outlined by the author, and colleague Ali Mahdmina in the November issue of *Tunnels and Tunnelling*, to coincide with the publication of their paper at the World Road Congress on 'facilities for persons of reduced mobility in road tunnels'

possibility as part of their planning process.

So what are the particular issues that might affect those with reduced mobility in the event of a tunnel-related emergency?

- Currently, there is no universally accepted form of identification for a private car or adapted van carrying a disabled person, nor means to signal they are in distress.
- Vehicles adapted for use with a chair lift need at least three metres clearance to the rear to permit egress. Those driving adapted vehicles need to be able to open the passenger door fully to open their folding chair and transfer into it.
- Clear passage towards an exit on a congested roadway may not be possible for someone in a wheelchair. Additionally, there is an increased risk of the infirm being pushed over or brushed aside by persons to the rear moving at a quicker pace.
- S.O.S telephones at emergency points/niches are generally fixed too high or beyond reach for wheelchair access.
- A raised kerb, elevated walkway transition, and/or a pedestrian impact guardrail presents a considerable, and sometimes insurmountable, barrier at an entrance lobby to a fire exit door.
- Raised concrete walkways up to 1.5m high which lead to exit doors, can only be accessed via climbing steps at periodic intervals. In previous emergency exercises it has been noted those with mobility difficulties pass by elevated cross tube escape doors in the belief they could reach the tunnel portal instead.
- Emergency exits at up to 500m spacing, as specified in European Directive 2004/54/EC, are too far apart for a person of reduced mobility, moving at around 0.5m per second, to reach a place of safety, unaided, before being affected by uncontrolled smoke. In the UK however most escape doors are spaced at 100m as per BD78/99.
- Stainless steel exit doors, particularly the self-closing sliding type, are either too heavy, or awkward, to open without assistance.
- Although most escape routes feature emergency level battery protected lighting, general in-tunnel lighting levels are often insufficient for persons with impaired vision, especially when affected by smoke.
- Emergency signage is generally inappropriately sized, and in some cases, coloured, for persons with impaired vision. Text size has traditionally targeted those with what is perceived to be "average or normal" eyesight, with no allowance or reasonable adjustment for the partially sighted.
- In some countries, even where there is step free access from the road into a fire exit, onward passage to a pressurised safety refuge, or parallel escape gallery, is negotiable only by climbing stairs. Compliant ramps or lifts for wheelchairs are a rarity

Below: Image illustrating an easily accessible escape route

ITA ASKED TO SET THE STANDARD

Alex Conacher
The *Tunnels and Tunnelling* Editor has been with the magazine since 2010

A key standard for mining and earthmoving machinery will not reference tunneling in any way, something that the *International Tunnelling Association Working Group for Health and Safety* wishes to avoid happening in future. **Alex Conacher** speaks with **Donald Lamont**, animateur of *Working Group Five*

AT THE World Tunnel Congress in Dubrovnik, two bodies of the ITA met to discuss ITA participation in Standards making. This interest comes after concerns were raised over the omission of tunnelling activities from the scope of EN ISO DIS 19296 'Mining and earthmoving machinery – Mobile Machines working underground – Machine Safety'.

Donald Lamont, chairman of the ITA's Working Group on Health and Safety (WG 5) invited a delegation from the ITA Committee on Technologies (ITAtech) to discuss a recommended ITA response to this omission.

- There are hazards specific to the underground environment which are not addressed by existing Standards for earthmoving machines, concrete spraying machines etc
- In legal terms, mining and tunnelling can be different activities with different regulations
- Mining and conventional tunnelling are indistinguishable from the machinery safety perspective
- The market is too small for separate Standards for mining and tunnelling machinery use
- Some of the technical requirements in the ISO DIS are of a lower standard than those set out in EN 16191 – TBMs and EN 12111 – Roadheaders

ITAtech and WG 5 agreed that there should be a single EN/ISO Standard setting out the generic requirements relating to the use of machinery underground. Such a Standard should cover generic requirements such as fire, visibility and emissions, and there should be the capability to include additional requirements for specific machinery types including those for personnel lifting, personnel transport and concrete spraying.

And additionally, in a report to the General Assembly in May, WG 5 and ITAtech issued the joint recommendation that "ITA should recognise its potential ability to act on behalf of the tunnelling industry through influencing the content of relevant CEN and ISO Standards and look to put in place technical and financial resources to address Standards participation in future."

***Left:** Relative comfort within a refuge chamber, the requirements of which are specified in ITA Guidelines but are not part of a Standard*

The period for comment on EN ISO DIS 19296 ended in the middle of May, so this time round the tunnelling industry has missed a significant opportunity, but there are ways it can increase its influence over future work.

PLAYING THE GAME

When it comes to voting for European Standards, each country in CEN has a vote 'for', 'against' or "abstention". For the TBM safety Standard EN 16191 there were only four countries involved in drafting that Standard: the UK, Germany, Switzerland and some input from France.

"There are over 30 countries in Europe who vote can for CEN Standards, so the majority of potential voters did not participate in drafting that Standard," says Lamont. "Some have a policy of abstaining, some have a policy of voting, irrespective of the fact that they have had no input into the Standard.

"Now of the CEN countries, some 28 of them are ITA members. If ITA could get itself organised it could influence the votes of these 28 countries. As only a small number

Donald Lamont
Donald is animateur of ITA Working Group Five, Health and Safety

of CEN member countries normally participate in drafting Standards, they could be easily outvoted by others."

MANHOLE COVERS

Lamont illustrates the point with an example from his time working on sewage and drainage Standards: "Manhole covers are a pretty mundane topic, but I was involved with the CEN Standard for them. Skid resistance requirements were a big issue for manhole covers. When motorcyclists corner hard, and go from an asphalt surface to a cast iron manhole cover and back to asphalt, they can lose the back wheel. Horse riders also struggle with their horses' hooves .

"One of these groups had a well-organised European organisation, which they subsequently mobilised because they were unhappy with the requirements in the Standard. Without warning , representatives from certain Mediterranean countries who normally did not participate in the process were voting against the Standard, on the grounds that that skid resistance needed to be taken more seriously. "

Through utilising the voting system like this the ITA could get tunnelling brought more directly into CEN and ISO Standards consideration. After all, the ITA has some 73 Member Nations to deploy. Lamont adds: "My suggestion is that the ITA actively seeks out Standards that impact tunnelling, and participates in them either with direct involvement, or indirectly for the benefit of the tunnelling industry."

Following this suggestion, the ITA requested a paper be prepared for ExCo discussion in September 2015. "The ITA needs to go and take part in the practical tunnelling world. It has to be professional. It has to actually do something. Look at PIARC. All their guidance is essentially mandatory in tunnel design and operation. This is what my paper will be about"

Above and right: ***Manufacturers were heacily involved in creating the ITA refuge chamber guidelines***

Standards explained

Throughout much of the 20th century, most countries drafted national standards for use in that country, through their national standards body. In the last two decades of the century, transnational standards bodies became dominant drafting standards, which were adopted in groups of countries. CEN is dominant in Europe – machinery safety standards, construction materials safety standards and Eurocodes, and ISO is dominant in the Americas, Australasia, parts of Africa and the Far East – machinery safety standards.

Standards making process
The process in CEN and ISO is broadly similar. A draft text is produced by a multinational working group of experts, that text is circulated to each national standards body (NSB) for enquiry vote and comment. Votes can be positive, negative or an abstention, with positive and negative votes normally accompanied by comments. After a positive vote the comments are resolved and a final text is produced. The final text is circulated for "formal" or "approval" vote. Assuming that is positive the standard is published. After a negative vote the text is revised and the enquiry circulation to NSBs is repeated

CEN standards
EC Directives must be implemented in each EC Member state. All machinery placed on the EC market must conform to the essential safety requirements of the Machinery Directive. Manufacturers normally choose to self certify compliance with relevant CEN standards to prove conformity. This makes CEN standards quasi-mandatory in Europe

ISO standards
ISO standards are highly influential. Conformity with ISO standards is voluntary unless a requirement of national legislation. Under the "Vienna agreement" dual ownership of standards can be agreed – creating EN ISOs. In the future most machinery safety standards will be issued as EN ISOs.

Working group membership
CEN and ISO working groups are made up of "experts" supposedly representing national standards bodies. "Experts" should be briefed by their NSB, but in practice the "experts" normally represent companies with commercial interests in the topic and act in their company interests. ITA although a multi-national organisation, is not eligible to participate directly in WGs but in practice there is nothing to prevent ITA Tech members persuading their NSBs to allow them to sponsor an employee to join a working group.

Other WG 5 business

- Version two of ITA Report Number 10 "Guidelines for good working practice in High Pressure Compressed Air" has been revised jointly with the Compressed Air Working Group of the BTS and was launched at the ITA Open Session in Dubrovnik.
  The report content has been increased by around 30 per cent mainly due to additional guidance on saturation exposures
- WG5 recognised that refuge chambers were now installed on all TBMs large enough to accommodate them but were somewhat concerned at the low uptake of chambers in conventional tunnelling. WG5 reiterated the need for regular comprehensive training for all persons who might need to use chambers
- WG5 had a presentation from South Africa about progress being made by SANCOT on a guidance document about safety in shaft construction. This is a work in progress, and not much is known about an expected delivery time or if it will be published with ITA
- WG5 had a presentation from France on progress being made by AFTES GT27 with the revision of their guidance document on tunnel ventilation
- Switzerland volunteered to coordinate a revision of ITA Report Number One "Guidelines for good occupational health and safety practice in tunnel construction, last revised in 2008. Proposals for the revised text are to be submitted to Switzerland by the end of September, with the aim of a revised report at WTC 2016.
- As for other future work, Lamont promises that WG 5 will have a "surprise item" to present in 2016. It is to be a "downloading of experience" from one of the members on a slightly niche topic, but of substantial importance to Europe.

IN THE CHAMBER

MineArc reflects on the industry one year on from the publication of ITA refuge chamber guidelines, and releases a tunnelling-specific range of chambers

Why do you need a brand specifically for the tunnelling industry?

Different industries call for varying specifications when it comes to refuge chambers and safe havens. MineARC has developed the TunnelSAFE brand specifically for the tunnelling industry, in order to offer a range that ticks all the boxes in regards to industry guidelines and requirements.

Within the TunnelSAFE range we offer various chamber designs, suited to different tunnelling projects and applications. Our Gantry Design chamber is mounted at the rear of the TBM cutting head infrastructure and provides a fixed safety solution for the life of the project. The Rail Design chamber is also designed for TBM projects, but is commonly mounted to a tunnelling rescue train in order to provide portable safe refuge in the event of an emergency. Finally, we offer a range of free standing chambers for conventional, or Drill and Blast, tunnelling projects. Their portable design allows for continual re-positioning throughout the life of the project.

ITA's Health and Safety Working Group noted that price was an issue for chamber uptake in conventional tunnelling. Are chambers designed for these jobs cheaper for that reason?

Drill and Blast chambers for conventional tunnelling jobs are more economical than our Gantry Design refuge chamber as they are more standardised. Every Gantry mounted chamber will be engineered to fit on its gantry mount.

Are there any parts of the world where you have seen a particularly large increase in sales?

The largest growth we have seen is in traffic and utility tunnels in Europe, particularly France, Germany, Austria and Albania. The reason for this is because of the enforced and more widely accepted regulation of refuge chambers in tunnel construction. With the new guidelines brought in by ITA we saw a generally large increase in interest in Tunnelling Refuge Chambers, however with respect to the EN it is more specifically an update to the old BS and more specifically focused towards OEMs who had adhered to the existing BS guidelines

Refuge chambers are strongly required in Germanic countries, unusually also for conventional tunnelling. Do you think the rest of the world can learn from their example?

Absolutely! Any time you are working underground the risk of accident and injury grows exponentially. To this end we advocate for safe refuge to be an integral part of the planning process for all underground industries. Unfortunately, quite often investment in safety on projects is not prioritised unless there is enforced regulation in place, and regulation is often only enforced after a major accident exposes risk.

What is your largest single project order?

The Doha Metro Project in Qatar will see a total of 17 MineARC TunnelSAFE Chambers commissioned over the life of the project.

Have you noticed any trends in the type of refuge chamber ordered by clients?

This is purely based on purpose and application, and also at what stage of the project they are at. The Gantry Design is our most popular tunnelling chamber model, sitting at the rear of the TBM. We are now starting to see an increase in the Rail Design however, as clients are starting to appreciate the value of a portable refuge chamber that can move through the tunnel for servicing and whilst occupied in an emergency situation.

Ideally however, clients adopt both models into their Emergency Response Plan (ERP). This offers multiple escape or refuge options in the event of an emergency.

What research and development is ongoing with chambers?

MineARC's research and development team are constantly looking at ways to improve existing systems and bring new technologies to the underground safety industry. They work closely with each client to develop the most suitable solution for the project in order to best optimise their safety procedures.

Recently we released the Compressed Air Management System (CAMS) – a breathable air system that is unique to the market and offers a range of features aimed at reducing running costs and improving operational safety during an emergency.

Aside from providing clean breathable air through a superior four-phase filtration process, some of the major benefits of CAMS include; optimisation of mine air services, guarantee against over pressurisation of the refuge chamber, gas toxicity monitoring, flood protection, and reduced service time during filter change-out. Third-party testing has shown that over a 12-month period, CAMS can equate to significant financial savings of around 95 per cent in mine air usage.

The ITA WG would quite like to see refuge chambers built into an ISO requirement, can manufacturers help that in any way?

Absolutely, as the development of underground safe practice and refuge is central to refuge chamber manufacturer's business. We live and breathe this every day. Our expertise in both the design and best practice for operating refuge chambers would provide valuable insight for the development of an ISO code for tunnelling refuge chambers

Alex Conacher
The *Tunnels and Tunnelling* Editor has been with the magazine since 2010

Healthy and Safety coverage sponsored by mineARC SYSTEMS

BREATHE FREELY

British efforts to mitigate the effects of occupational exposure to harmful respirable material are led by Breathe Freely, a new health initiative. Editor **Alex Conacher** reports from a British Safety Council seminar in Cardiff, Wales

INDUSTRY BODIES are making a push for companies to take notice of health in the workplace as much as safety. In the UK as a whole, Health and Safety Executive (HSE) statistics from 2013/14 show that around 13,000 people die from work-related diseases, while some 133 people died from accidents.

The British Occupational Hygiene Society (BOHS), which prefers to refer to itself as the Chartered Society for Worker Health Protection, wants to target the 99 per cent of cases, rather than the one per cent.

And looking specifically at UK construction, BOHS claims that there were 42 fatal injuries to workers last year, but 5,500 new occupational cancer cases, 5,000 deaths from asbestos, and 500 deaths from exposure to silica dust. So lung disease prevention is where the focus will be for the construction industry.

BREATHE FREELY

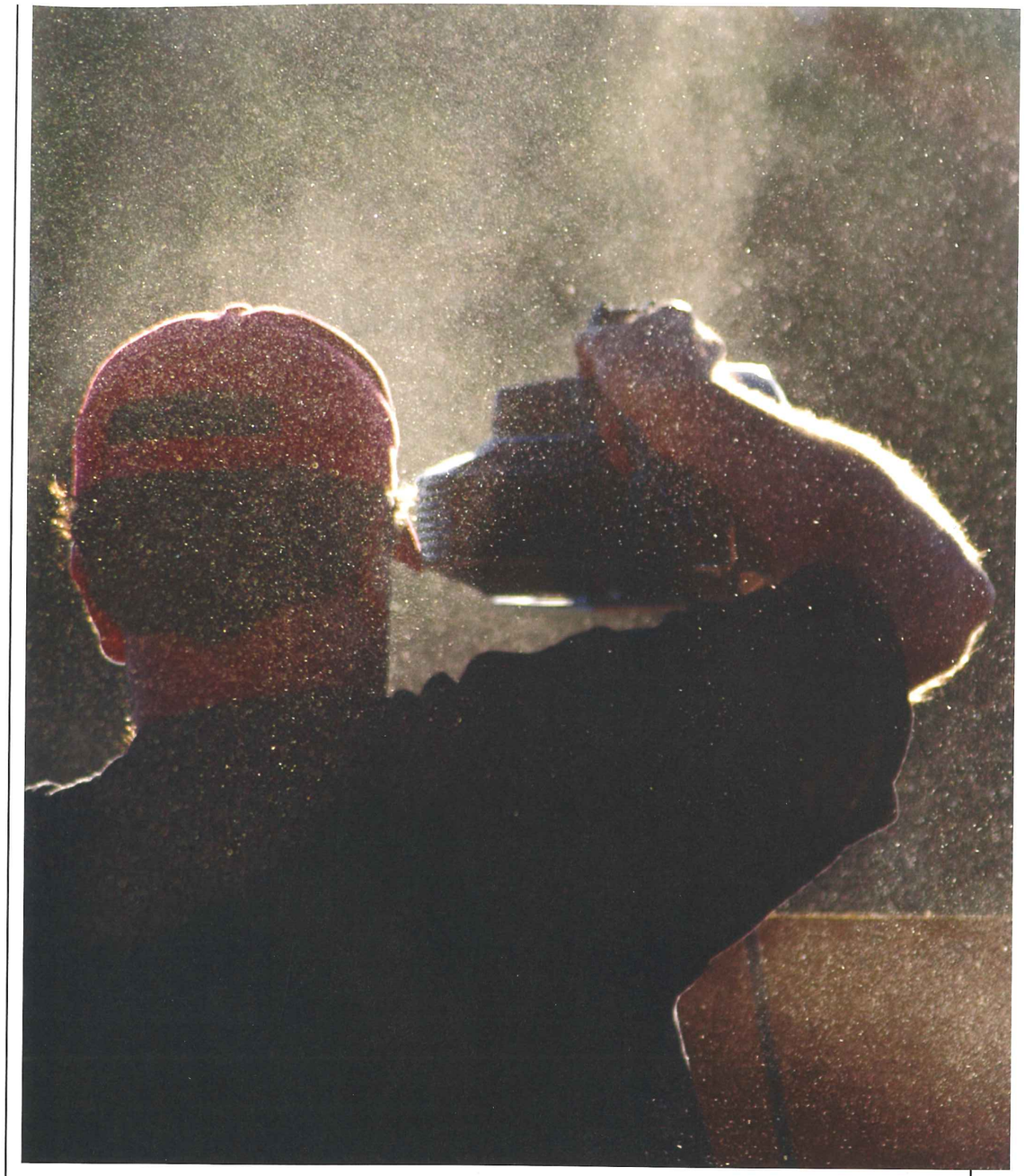
The initiative put forward by BOHS to raise awareness of and prevent these health issues is called 'Breathe Freely' [1]. It was launched on 28 April to coincide with Worker Memorial Day. A BOHS spokesman said at the time: "Breathe Freely is a collaborative initiative targeted specifically at managers and site supervisors within the construction industry. The aim is not just to raise awareness of the problem of lung disease within construction industry, but also to effect action by providing practical solutions through sharing of best practice and encouraging implementation of effective exposure control.

"At the heart of the Breathe Freely initiative is a new Worker Health Protection Management Standard, a tool to help employers tor reduce health risks, raise standards and keep them high."

As well as a suite of general resources for businesses, such as documents explaining the purpose of occupational hygienists, the Breathe Freely team is working on several main initiatives, all aimed at management.

- Firstly, building on existing materials from the HSE, such as the worker information cards [2], the organisation has prepared hazardous activity fact sheets to brief decision makers on practices they may not be familiar with. One example describes the role of, and dangers to a 'concrete sprayer' [3]. These cards also link to related documentation, in case HSE air sampling procedures.
- The implementation of The Health in Industry Management Standard (HI). This provides a "six point framework of good practice" to help companies of all sizes to introduce, manage and improve their Worker Health Protection programmes, ensuring that the health risks are properly recognised, evaluated and controlled. The points are, in summary: Demonstrate that Worker Health Protection is valued; Assess the actual risks to health from workplace activities and substances (don't just list the hazards); Ensure that every worker is on board, is competent in, and takes ownership of, their own health risk management at work; Eliminate and minimise risks to health early on: design and plan them out wherever possible; Adopt the most effective and appropriate exposure controls to prevent ill health and disease; Manage Worker Health Protection all the time: over the whole site, before and throughout every project, and from the top to the bottom of the company. See references for a link to the document [4].
- A toolkit is being produced as Tunnels and Tunnelling goes to press, and is due to be released in November. It will cover common risks, an audit checklist, visual standards, practical guidance on COSHH & RPE and toolbox talks.
- To sweeten the deal for management, Breathe Freely has also gathered together a number of case studies to show the practicality of their processes, and also their cost effectiveness [5]. Through the link in the references, there is also a lengthy essay arguing the benefits of occupational health from the points of view of: finance, employee relations, social responsibility and reputation. It concludes: "In short good occupational hygiene intervention is good for your business, whether it be from a financial benefit, protecting the health of your staff in the longer term, or ensuring you have a strong commitment in terms of legal and social responsibility, all resulting in the protection and enhancement of your reputation."
- Finally, a directory of all companies able to provide occupational hygiene services in the country has been provided, along with information necessary for making the decision of which to go with.

Alex Conacher
The *Tunnels and Tunnelling* Editor has been with the magazine since 2010



INFORMATION SHARING

The initiative is still at a stage of relative obscurity, but is actively seeking exposure. Kelvin Williams of BOHS regularly gives presentations to emphasise what he describes as "the curse of latency" – the problem that health issues can take decades to appear.

"So the statistics do not tell the full story," says Williams, speaking at a British Safety Council (BritSafe) seminar in Cardiff in May. "Everyone knows that construction sites are a risky environment. There have been more construction workers killed in the last decade than soldiers; construction accidents make the front pages of newspapers, and with their blood and gore they are a risk people can easily

Above: ***Occupational health issues can emerge decades after exposure***

understand. But other health hazards, especially those posed by silica dust (which has recently been classified as a carcinogen), are too often overlooked.

"Raising awareness is vital to starting the process of eliminating these hazards. If you look at those HSE statistics: 13,000 workers killed every year by occupational health issues.

"That is the equivalent of 2.5 jumbo jet crashes every month without survivors.

"And yet people do not fully appreciate these risks, we are caught up in the 'Safety' part of 'Health and Safety', and neglect the 'Health'."

Invisible menace

One of the biggest challenges to recognising the threat is that the particles are tiny. Respirable crystalline silica, which is of the order of a 10µm diameter, is very hard to see, except in cases of gross exposure, according to Williams.

To demonstrate, he pulls out a climber's chalk bag and expels some material into the air, which promptly vanishes. Then, applying torchlight, the presence of dust is clearly seen. And the defined 0.1mg/m³ exposure limit is miniscule.

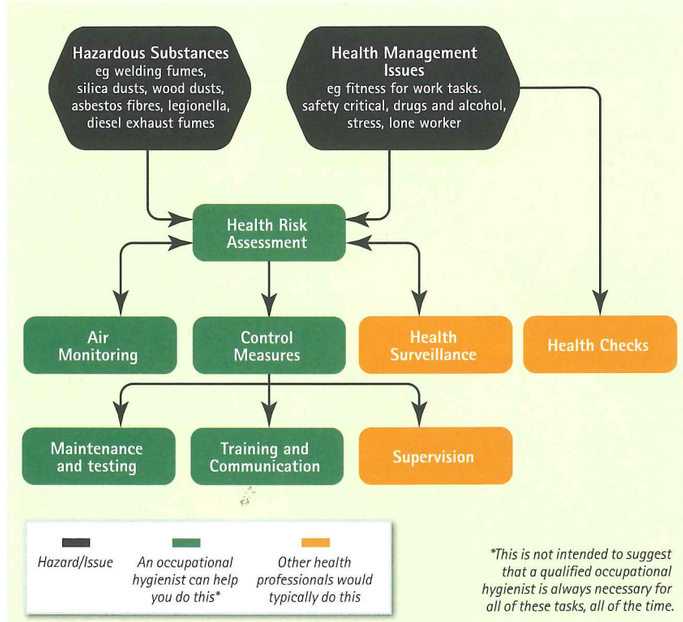
Other scenarios being addressed by the initiative include asthmas and nasal cancers from wood dust, and deep lung and cancer problems from solvent and diesel (exhaust) emissions, as well as welding fumes. Equally, these can be difficult to observe.

Williams adds, "There was one company – I won't mention the name – that told me 'this report is killing us' in response to an inspection that showed twice the nickel exposure limit on site. You have to appreciate the irony."

Point of contact

A past report prepared by the Health and Safety Laboratory (HSL) for the HSE [7] observes that poor application of workplace controls, even in spaces with a good occupational health culture, was a threat to worker health: "All sites visited were trying to apply what they perceived as reasonable controls for health and safety. Although, even in dusty areas, most workers did not wear masks."

Williams adds that PPE supplier 3M Masks has estimated that 80 per cent of masks are wasted through incorrect use.



*This is not intended to suggest that a qualified occupational hygienist is always necessary for all of these tasks, all of the time.

***Above:** Flow chart showing what an occupational hygienist can help with*

Corporate repercussions

The BritSafe seminar continued with a legal presentation by Chris Green, a 'leading health and safety prosecutions lawyer' from Weightmans LLP. It was an interesting scheduling decision.

In case the arguments relating to worker health and corporate responsibility did not win people over, a lecture on corporate manslaughter and health and safety legal issues should work.

Green levels a number of warnings to the delegates, and one that should resonate strongly was the legal change that magistrates can, since 12 March, order unlimited fines for health and safety offences, while the previous limit was GBP 20,000 (USD 31,000). This is a great risk as magistrates are inexperienced with such cases, and the outcome can be uncertain

References

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2 – http://www.hse.gov.uk/pubns/indg172.pdf
3 – http://www.breathefreely.org.uk/assets/concrete_sprayer_fact_sheet.pdf
4 – http://www.breathefreely.org.uk/assets/breathe-freely-hi-standard-top-tier.pdf
5 – http://www.breathefreely.org.uk/what-is-occupational-hygiene.html
6 – http://www.bohs.org/OHServices-directory/
7 – http://www.hse.gov.uk/research/rrpdf/rr878.pdf

Useful links

The Construction Dust Partnership:
http://www.citb.co.uk/health-safety-and-other-topics/health-safety/construction-dust-partnership/controlling-dust/
HSE cancer priority areas (silica):
http://www.hse.gov.uk/aboutus/occupational-disease/cancer/silica.htm
HSE dust frequently asked questions:
http://www.hse.gov.uk/construction/faq-dust.htm

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VERMEER ADDRESSES 'GOLDEN AGE'

Manufacturer *Vermeer* hosts a Media Summit at its headquarters near Pella, Iowa to discuss challenges facing the underground construction industry, and launch a new range of equipment that its engineers believe will help contractors rise to the impressive pipeline of work available

CHRIS DAUM asks "have we [in North America] entered the Golden Age of Underground Construction?" Daum is president of FMI Capital Advisors, a consulting and investment banking firm dedicated to construction and argues that yes, they have. He is speaking at a media summit hosted by horizontal directional drill manufacturer Vermeer at their headquarters in Iowa, USA and is one of several guests invited to assess the market into which Vermeer is launching a new range of HDD rigs.

"The acceleration of XLPE installation is high, and gas replacement for aged or substandard infrastructure is going through a quadrupling," says Daum, "but even at the current rate of replacement, we're looking at over 54 years to replace everything on the wish list. And midstream oil and gas pipelines just have to be built. No question."

As for new installation, Daum adds: "The 'Internet of Things' will dwarf current connectivity. The telecommunications boom is just starting. Google want to drive the future of connectivity, and their spending pushes the world to do the same.

"Never in my career has their been such a sustained favourable outcome, and spending, across all underground sectors. What do I think of the future? I can't think of a better time.

There are challenges, however. "When it comes to the undergrounding of existing overground infrastructure that is functional, we are moving slowly. That is simply too expensive. Possible four or five times more expensive. Aside from this, the financial crash caused the worst construction downturn in a lifetime. Utility infrastructure as a whole not hit too badly,

Below: D40x55 S3 in operation pulling product

but the broader construction market lost 30 per cent of its workforce. Now we face a serious shortage.

"The market pipeline is 20 per cent higher than in 2014, and expected to double in 2016 despite the price of oil, however the oil price has made the work hyper-competitive. Previously a lot of easy work was being performed by unsophisticated companies, now the supply line is compressing and there is pressure to get better. All the while margins are being compressed."

Vermeer's vice president for underground products Dave Wisniewski provides his analysis of Daum's market report: "What you see is that the main demand for underground solutions is situated in the urban environment. Telecommunications and gas distribution are the two primary drivers for the use of this equipment, and that is in your neighbourhood, down your street. And so the challenges of working in built up areas need to be considered as well as the more general challenges facing the industry."

SERVING THE GOLDEN AGE

Wisniewski describes four to five years of market research, working out and addressing the concerns of contractors, which he says come down to three issues: noise level (to avoid irritating nearby residents), simplicity of use (to reduce the burden on a severely undermanned workforce), and of course speed. The result, he says, is their S3 range.

Sound reduction is self-explanatory, and Wisniewski cites volume reductions of over 50 per cent in some of the new models, which are also all Tier 4 final engines with a Tier 3 option for less regulated countries. The D23x30 model actually has an operator ear rating of 78.7dB and does not technically require ear protection.

Vermeer's S3 range 'vents' sound out of the back and upwards through a chimney. A Vermeer engineer said that in some cases this has needed a word of advice with some trial operators, as one or two have been throttling high thinking the machine is not working properly. The noise reductions are that effective. As for the simplicity aspect, he Wisniewski: "The fact is that we just do not have enough operators to function and drive the machines. The key way to mitigate this is to allow operators to be moved around, and for this we tried to achieve commonality between the different sizes of machines. All of the rigs are similar, even from a service perspective they use common components."

Speed isn't just drill time, it is getting the rod in and out of the ground, faster tracking speeds, getting the rig from drill site to drill site. Short distances, for example a couple of blocks, the machines can move under their own power. And an encoder that stops the drill rod where it needs to be broken (rather than relying on a physical, makeshift marker), improves cycle time.

Other features to serve these goals, such as a rod shield that complies with EU rod guarding standards seem less important in the sweeping avenues of North America, but look much more applicable warren-like roadways likely to house worksites in the European market.

Above, left: A D40x55 operating in a constrained location near a road

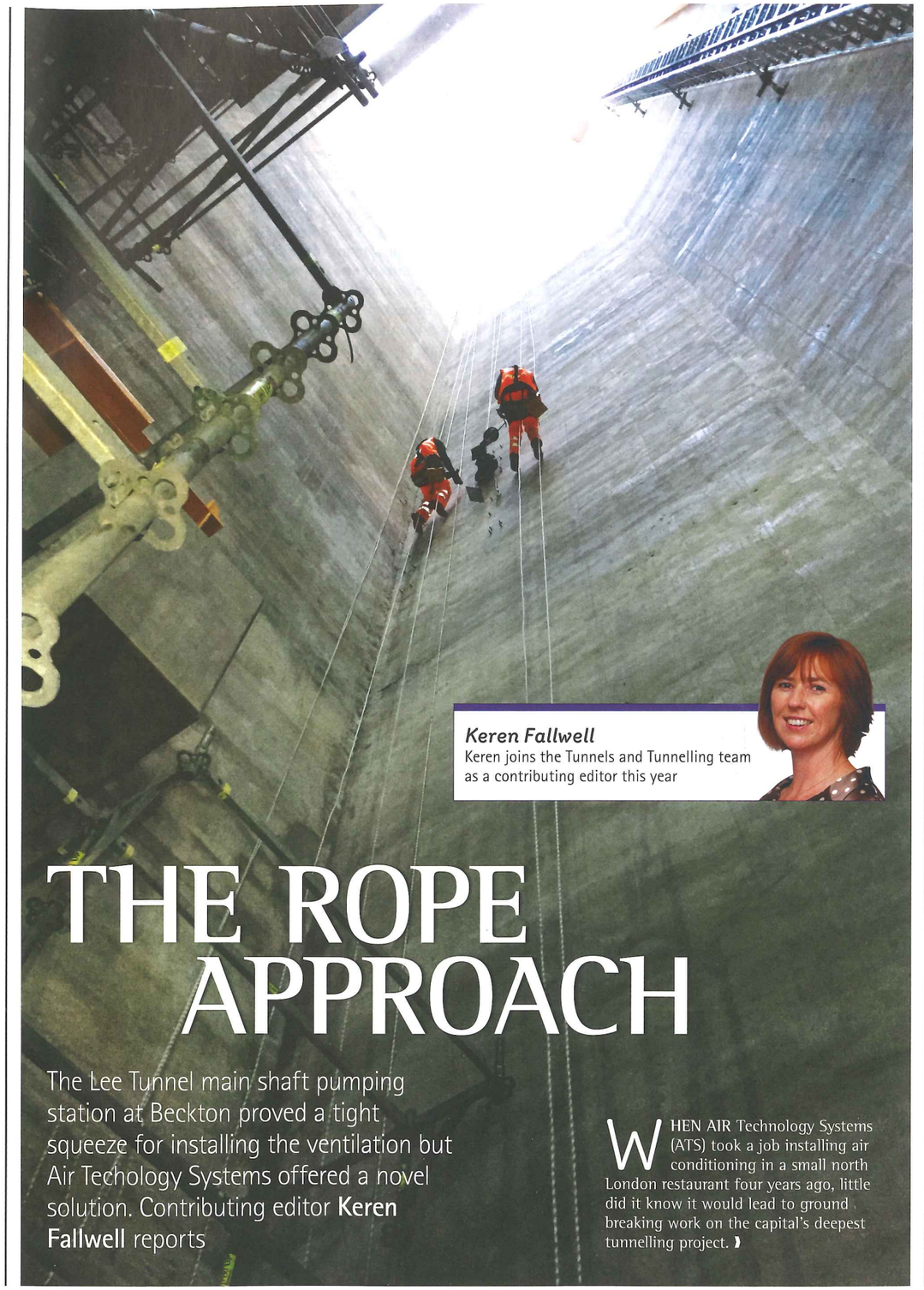
Above, right: The D23x30 runs at 78dB at the operator's ear, so falls below the 80dB OSHA threshold

RUNNING A BUSINESS

Jon Kuyers, senior global underground product manager for Vermeer, gave a presentation on business challenges facing the contractor in an age of increasing paperwork. The company's solution is a suite of electronic 'Productivity Tools' called InSite. "There are key office challenges to overcome. Multiple stakeholder demands mean that data-based answers need to be provided, and with paper systems the record-keeping can be haphazard. It's difficult to collect, store and share data. This results in time wasted, lost opportunities, and less time pursuing work."

Other tools assist with fleet management and tracking, bore planning, and logging of alterations to the plan on site. The company says it allows for informed decisions from the start, right the way through to invoicing, with sophisticated and easy record keeping.

Doug Hundt, Vermeer president for industrial solutions adds: "Everyone here has a Smartphone. Ten years ago, that would not have been the case. No longer does paper need to go point-to-point. Bringing the digital lifestyle people experience into construction is the future. And it's going to happen quickly"



Keren Fallwell
Keren joins the Tunnels and Tunnelling team as a contributing editor this year

THE ROPE APPROACH

The Lee Tunnel main shaft pumping station at Beckton proved a tight squeeze for installing the ventilation but Air Techology Systems offered a novel solution. Contributing editor **Keren Fallwell** reports

WHEN AIR Technology Systems (ATS) took a job installing air conditioning in a small north London restaurant four years ago, little did it know it would lead to ground breaking work on the capital's deepest tunnelling project. ❱

The restaurant was on the ground floor and in the basement of an old building in Kentish Town and the only means of getting services to the roof was to dismantle a lift shaft and use it as the core for the extract ducts, electrics, plumbing, gas and air conditioning.

The problem was, once scaffolding was erected in the shaft there wouldn't be room to run the services. The answer was rope access.

"I used to be a keen climber," said ATS contracts manager Pete Dimmick. "I was in a climbing centre one day and I thought, that's the way to do it."

Dimmick, whose natural climbing environment was the peaks of northern England rather than a lift shaft in north London, and three tradesmen completed an Industrial Rope Access Trade Association (IRATA) level 1 rope access course, and a level 3 was hired for the necessary supervision requirements.

"It was a success and opened doors to new opportunities if we had to install in difficult places," said Dimmick.

Midlands-based ATS used the technique on various subsequent contracts to run services in tight spaces, generally to a roof or in the horizontal space below a roof. Now it has taken it underground in the Lee Tunnel, Britain's largest water engineering project for 20 years.

THE PROJECT

The Lee Tunnel is the first of two tunnelling projects which form the Thames Water London Tideway Improvement Scheme, the so-called "super sewer" designed to reduce storm discharges into the River Thames and River Lee.

The completed scheme will capture an average of 39Mt of sewage a year from the 35 most polluting combined sewer overflows (CSOs) built by the Victorians as part of the sewerage network that still services London today.

The GBP 635M (USD 975.5M) Lee Tunnel – London's deepest tunnel – will tackle discharges from the capital's largest CSO at Abbey Mills Pumping Station in Stratford, which accounts for 40 per cent of the total discharge.

The four-mile, seven-metre diameter tunnel will run beneath the London Borough of Newham from Abbey Mills to Beckton. It will prevent more than 16Mt of sewage mixed with rainwater overflowing into the River Lee each year by transferring it to Beckton Sewage Treatment Works. The treatment hub is being expanded by 60 per cent to deal with the increased volumes.

The MVB joint venture, comprising Morgan Sindall, Vinci Construction Grands Projets and Bachy Soletanche, began construction of the new main pumping station at Beckton in 2010 and, after much input from ATS managing director Steve Boon and operations director Rebecca Clissett, ATS was awarded the ventilation package in 2013.

The pumping station is being constructed within a 38m-diameter, 80m-deep shaft and will be divided into two dry well compartments which will house the pumps and motors to pump the storm water and sewage into the treatment works. The facility has two designated access shafts to allow safe ingress and egress for maintenance.

When MVB awarded the work to ATS, the joint venture didn't know the company had a rope access division and was expecting the work to be carried out using the traditional man riders and scaffold.

However, it quickly became apparent to ATS that the space was too tight to accommodate a man rider, men and ductwork, some of which was 2.2m in diameter.

"Man riders sit 2-3m proud of the wall so rope access was the only way for a person to get in, install the ducts and do

Both: Work was efficient and relatively unaffected by changing weather conditions outside the shaft

up all the bolts. Man riders couldn't do it and neither could scaffold. We knew that rope access was the way to install it," said Dimmick.

MVB was eventually persuaded that the unconventional rope access was a feasible solution. In terms of safety, time and cost, for ATS it was a no-brainer.

"The dividing wall in the shaft slants so without ropes we couldn't have done it," said ATS project manager Jonathan Moore. "We would have had to stage it – put a section in, build scaffold, build another section – which would have taken longer."

Also, using scaffold and man riders would have required two cranes, increasing the project's environmental impact.

The tight access aside, erecting and striking 30m or so of scaffold would have required extra programme time, created crane lifting restrictions, posed safety issues and added cost.

"Scaffold puts restrictions on everyone else – you can't lift and you can't work underneath it.

"Using rope access, we have an exclusion zone below us when we're working but that's it; it doesn't interfere with anybody else's work," said Moore.

In addition, ATS has been immune to the weather-related problems that have slowed down some other contractors.

"Man riders can't be used when the wind is more than 7m/sec but that doesn't affect us because we're inside the shaft and it's a different climate," said Moore.

ATS says the process, from setting up on site to day-to-day working, has been efficient too.

"To start on site we just needed to install the rings for the ropes on the rim of the shaft. It took three hours and we were ready to go," said Dimmick.

ATS has eight tradespeople trained in rope access and five of them – two duct fitters and three plumbers – have been working on the Lee Tunnel contract.

MINIMAL DISRUPTION

It takes the team only a short time to don their climbing harnesses and, once they've descended the shaft, the ductwork is lifted in by crane. One of the Level 2 qualified men has also been trained as a banksman so all the banking can be done from the ropes and no-one else is required.

"We're not restricted by anyone else, we're clean in our operation and we're self-contained," said Dimmick.

ATS started installation in October last year and for seven weeks, including over some of the cold winter months, it ran a day and night shift continuously. There is no limit to the length of time the rope access team can spend in the shaft and they would typically be down for five to six hours, with food and water fed down on ropes.

"When you're in a harness the weight is taken off your legs and we can access all points in the shaft," said Dimmick. While the work is rewarding, it's not for the faint-hearted.

"The work is physical anyway and you're adding another element to it," he said. "Once you're in that space you have to keep going. It's intense, but it's satisfying as well."

The installation work threw up no surprises for ATS and the only changes made were to the sequencing of works.

"For the first few weeks we did all the drilling then changed the sequencing to make us more efficient," said Moore. "We got faster and faster and it developed to installing the brackets and four pieces a night."

Rope access has been such a success for ATS that it will now offer IRATA rope access training to its plumbing and air conditioning apprentices, which it takes on through South & City College Birmingham.

The apprentices have to be 18 years old before they can

The ventilation system

The pumping station shaft will have six 3MW pumps to transfer the sewage and storm water for treatment at Beckton Sewer Treatment Works.

The ventilation systems that Air Technology Systems (ATS) is installing in the shaft are designed to provide a safe working environment in an area that can be subject to the presence of hydrogen sulphide and high temperatures created by the large pumps.

Air is supplied to both sides of the shaft via large plants located outside the shaft. Large vertical ductwork distributes air evenly throughout the dry wells and ATS's JETFLO air induction nozzle system injects air at high velocity into the space.

"The Jetflo nozzles are key to achieving a high ventilation efficiency by thoroughly mixing the air, diluting any heat and contaminants, such as hydrogen sulphide, and creating the best possible working environment," said contracts manager Peter Dimmick.

The system is self-balancing so it maintains a safe environment for people to enter.

Hydrogen sulphide is heavier than air so extracting from low level from both sides of the shaft is another key design feature.

Pumps are also situated at low level to enable the heat to be captured at source and exhausted outside.

The access shafts have different design requirements, incorporating the need to provide general ventilation to the stairways, but also to pressurise the entire access shafts for firefighting.

All the access shaft ductwork systems are 316 stainless steel, which is fire-rated for four hours.

undertake the IRATA training.

"The college is using this as a test case and if it works they'll create a new syllabus for it, which will be the first of its kind," said Dimmick.

It's all part of ATS's plan to expand its rope access division and provide construction projects with a new solution for working in difficult spaces.

The Lee Tunnel is the largest project ATS has tackled using rope access and Dimmick said the company would consider the technique for any job.

"We want to create a new industry," said Dimmick. "Everywhere in construction people are struggling and scratching their heads. Nobody has thought of anything apart from traditional methods of access such as scaffold towers, man riders, cherry pickers or scissor lifts."

And he suspects that ATS is now blazing a trail that others will eventually follow.

"Rope access is used for window cleaning on high-rise buildings but we're the only company that has taken qualified tradesmen and taught them rope access," he said. "I think that other companies will follow our lead – most likely a rope access company employing tradesmen and training them rather than a construction company because they tend to be more risk averse."

FIRM BUT FAIR

However, the IRATA training is no small undertaking. It is physically demanding and, according to Dimmick, only one in four people passes.

"It's the hardest thing I've done both physically and mentally; you have to have self-confidence. However, the accident rate in rope access is very low because of the stringent training we go through," he said.

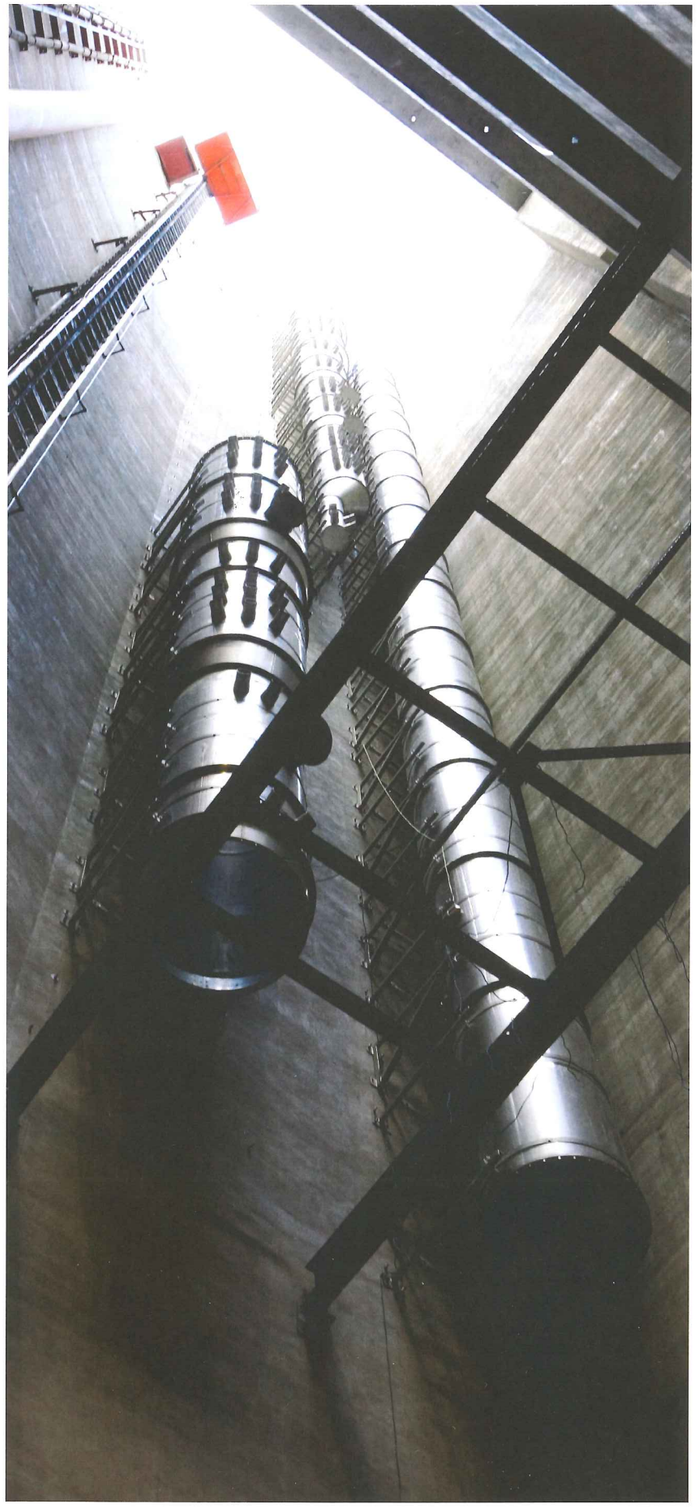
"When someone does have an accident it's because they've not followed protocol."

Moore agrees that rope access, with its safety track record and cost-effectiveness, meets a need on construction projects that are becoming larger and ever more demanding and sophisticated.

"It's the future for doing this type of work; we've set a precedent," he said.

MVB has been so impressed with the efficiency of rope access that it has now approached ATS to do the maintenance on the ventilation, plumbing and pipe fitting works at Beckton.

"We've hit the programme on time and had no incidents or accidents," said Dimmick. "We've proved that the method works"



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BRITISH TUNNELLING SOCIETY

What's on

2015

Tunnel Expo Turkey
27-29 August 2015
Istanbul, Turkey
Turkey is fast growing in the tunneling sector. This event namely Tunnel Expo Turkey focuses on the fast growth.
www.10times.com/tunnel-expo-turkey

Crossrail's tunnelling story exhibit - final day
31 August 2015
London, UK
The final day of the six-month exhibit on Crossrail at the London Transport Museum in Covent Garden falls at the end of August. The exhibit is open seven days a week for the majority of the day, so don't miss out.
www.ltmuseum.co.uk

Underground Design and Construction Conference 2015
11-12 September 2015
Hong Kong
The Hong Kong branch of the Institute of Materials, Minerals and Mining expects to have over 500 delegates and numerous exhibitors, building on the 2009 event. Keynote speakers include N. Barton, M. Herrenknecht, C. F. Lee and L. Home.
www.udcc2015.com

Bauma Conexpo Africa 2015
15-18 September 2015
Johannesburg, South Africa
The premiere of bauma Africa in September 2013 attracted 754 exhibitors from 38 countries and 14,700 visitors from over 100 countries. Covering a total of 60,000sq.m of exhibition space, this is the biggest event for the sector in Africa.
www.bcafrica.com

Health and Safety - what's next?
23 September 2015
London, UK
Get up-to-date insight from the industry's best. The BSC's annual conference will tackle key issues from across the health and safety landscape. It will give you the opportunity to gain insight into innovation and best practice in health and safety management, while networking with your peers.
www.britsafe.org

Roads. Bridges. Tunnels International Exhibition
23-25 September 2015
St. Petersburg, Russia
Roads. Bridges. Tunnels (the International Specialised Exhibition) takes place in St. Petersburg, Russia from 23 September to 25 September.
www.tofairs.com

ICUEE 2015
29 September-1 October 2015
Louisville, Kentucky
The largest demonstration show in North America for the construction and utilities industries. This biennial show attracts persons involved in the electric, cable, sewer/water, gas, construction and public works sectors. Hands-on, practical desmonstrations of construction and utility equipment are also planned to be held alongside the event.
www.icuee.com

Workshop on Innovations and Challenges in Tunnelling
5-6 October 2015
Kingston, Ontario
Save the date for the TAC 2015 Workshop, AGM and annual awards dinner, to be held at Queen's University's Grant Hall in Kingston. Further details of the workshop including program and registration will be available in Summer.
www.tunnelcanada.ca

8th Annual Health and Safety Excellence Conference
7-9 October 2015
Amsterdam, Netherlands
This conference will help companies to develop their safety culture and achieve optimized technical safety through increased engagement. Cross-industry experts will deliver practical case studies on how they have successfully implemented an optimized safety culture
www.marcusevans-conferences-paneuropean.com

Eurock 2015 & 64th Geomechanics Colloquium
7-10 October 2015
Salzburg, Austria
The ISRM Regional Symposium EUROCK 2015 Future Development of Rock Mechanics, is to be held in conjunction with the 64th annual Geomechanics Colloquium also in Salzburg.
www.eurock2015.com

25th World Road Congress
2-6 November 2015
Seoul, South Korea
The World Road Congress has been held every four years for more than 100 years. Since the first meeting in Paris in 1908, it has toured the member countries of the non-government organization, Permanent International Association of Road Congresses (PIARC).
www.aipcrseoul2015.org

Controlling exposures and health risks in construction
10 November 2015
Birmingham, UK
The Breathe Freely campaign has been launched recently with a view to raising awareness of the occupational health issues related to respirable materials in the construction industry.
www.breathefreely.org.uk

ITA Tunnel Awards
19 November 2015
Hagerbach, Switzerland
The International Tunnelling Association has launched its own independent awards to recognise industry achievements. The first presentation will be held alongside a conference and banquet at the Hagerbach Test Gallery.
www.awards.ita_aites.org

Third Arabian Tunnelling Conference and Exhibition
23-25 November 2015
Dubai, UAE
This conference is the industry's opportunity to share the knowledge, projects and application experiences, and provide you the opportunity to hear what others have to say. Case studies, which show real-world applications and the implementation of new technologies.
www.atcita.com

Stuva Conference
1-3 December 2015
Dortmund, Germany
Held every two years, this conference sees 1,500 participants and visitors from about 20 countries. It is numbered among the world's leading get-togethers for underground construction experts. In 2015 the chosen venue for this premier event is Dortmund.
www.stuva-conference.com

Building simulation
7-9 December 2015
Hyderabad, India
This conference is the 14th International Conference of the International Building Performance Simulation Association.
www.bs2015.in

2016

International Symposium on Tunnel Safety and Security
16-18 March 2016
Montreal, Canada
Tunnel safety and security is a challenge for both private and public sectors. ISTSS provides a forum to discuss current practice and emerging trends and research in the field of tunnel safety and security. Each day will be opened by invited Keynote Speakers.
www.istss.se/en

NASTT's No Dig Show
20-24 March 2016
Dallas, USA
The overall No-Dig Show program is focused on one objective: helping you maximize your investment in trenchless technologies, services and applications. Owners, utilities and municipalities can immediately benefit.
www.nodigshow.com

Bauma 2016
11-17 April 2016
Munich, Germany
The 31st meeting of the world's largest trade fair for construction machinery, building material machines, mining machines, construction vehicles and construction equipment.
www.bauma.de/en

World Tunnel Congress and North American Tunnelling conference 2016
26-28 April 2016
San Francisco, California
The 2016 World Tunnel Congress (WTC) and the 39th General Assembly of the International Tunnelling and Underground Space Association (ITA) will be held in conjunction with the UCA's North American Tunneling conference. Bringing the three events together in the US is unprecendented.
www.smenet.org
www.wtc2016.us

GeoChina International Conference
25-27 July 2016
Shandong, China
This conference will provide a showcase for recent developments and advancements in design, construction, and safety Inspections of transportation Infrastructures and offer a forum to discuss and debate future directions for the 21st century. Conference topics will cover a broad array of issues
www.geochina2016.geoconf.org

British Tunnelling Society

The BTS has a membership of almost 700 individual and 60 corporate members. It is one of the most vibrant gatherings of professional tunnellers in the world and traces its history back to its founding in 1971.

Regular BTS monthly meetings are hosted at the Institution of Civil Engineers in London from 5.30pm every third Thursday of the month. In recent years, the BTS Young Members (BTSYM) have also begun hosting events.

Innovation and technology in segmental lining design
17 September 2015
A presentation by a tunnel engineer who has extensively published on topics related to segmental lining solutions. This talk will cover the future of segmental tunnel linings. The speakers stated: "Over the last 40 years TBM tunnelling and segmental lining technology has seen significant changes in the technologies adopted and how it operates. This presentation aims to stimulate industry-wide discussion by sharing our views on where we are, and where we collectively believe our industry is heading."
Speakers: Mike King, director at CH2M; Anthony Harding, global technology director for tunnels at CH2M; Malcolm Chappell, director at Ozengi Associates

Waterview Connection project in Auckland, New Zealand
15 October 2015
The Waterview Connection project is New Zealand's largest and most complex road construction project. The entire project - which also involves building the surface connections to the existing motorways, 9km of new cycleway, new community amenities such as walkways, playgrounds and skateparks, and planting approximately 150,000 trees and shrubs - is due to be completed in early 2017. It also includes one of the country's most challenging tunnels to-date: 2.4km of 14.1m-diameter twin bore. The Waterview Connection is one of five projects to complete the Western Ring Route as an alternative motorway to SH1 through central Auckland and across the Auckland Harbour Bridge.
Speaker: Chris Ashton, Waterview Connection project tunnel manager

BTS Underground Health and Safety Course
24-25 November 2015
The Health & Safety Course is organised and run by the British Tunnelling Society (BTS), an Associated Society of the Institution of Civil Engineers. The purpose of the course is to provide a comprehensive introduction to Health & Safety in tunnelling. It has been decided to repeat the two day format of the last five years to allow more time on specific subjects and include more discussion and debate.
Fees: BTS Members: GBP 100; Non-Members: GBP 150

BTS Christmas debate
15 October 2015
The traditional end of year debate will this year argue the proposition "This house believes that developments in recent years relating to sprayed concrete lining thicknesses is heading in the wrong direction, noting that sprayed concrete lining has managed to double the lining thicknesses in the last ten years". After hearing the arguments for and against, some more serious than others, a vote decides the issue.
Speakers for and against have yet to be confirmed

If you have a topic or project you feel would be suitable for a BTS evening presentation, please contact:

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See the society website for further information:
www.britishtunnelling.org.uk

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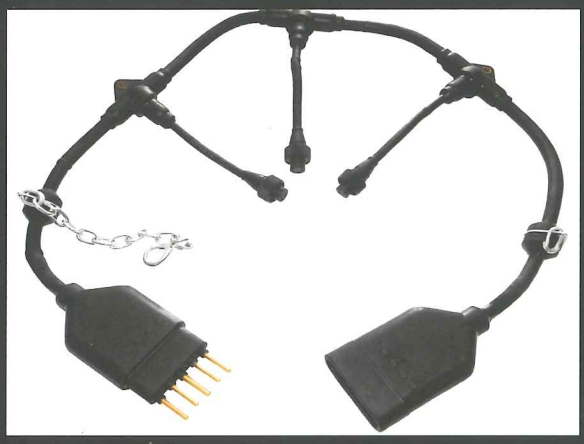

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