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August 2013

Tunnels

AND TUNNELLING



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VIRTUALLY REALITY

IN A darkened room beneath the massive Herrenknecht manufacturing plant in Schwanau, Germany, a man squats and stands and twists in front of a large screen. As he leans, the 3D graphic of a TBM on the wall in front of him distorts and warps to the eyes of everyone else in the room.

The squatting man is Alex Alfano, Herrenknecht's resident expert in the company's new toy. With glasses akin to those you get in an Imax, but with the added feature of four little antennas, Alfano is able to manipulate the screen with his movement. The effect when wearing the glasses is unbelievable. The wearer can twist left and right and get a very real 3D view of his surroundings.

I don the glasses. Alfano has positioned me near the in the shield of an EPBM just behind the cutterhead. Looking to the left I can see the drive motors, I can reach up to them. I look right and I can see the backup of the TBM. I lean into the screen and look right and I can see right down the entire length of the TBM.

The system, developed in Germany, is called ICIDO. To have a setup like that at Herrenknecht's offices will cost in excess of USD 100,000. The advantages and uses of the system have barely been explored.

The system takes just a few hours to convert the usual AutoCAD models into the virtual reality model.

Initially, Herrenknecht has been using the system to check how a man could perform various operation and maintenance tasks on compact machines. As TBMs become ever more complex and the machines become more congested, the lifelike 3D model allows the user to practice operations and ensure there is enough space for the task to be performed. It also helps engineers identify design clashes and by being able to properly visualise the machine they can find better ways to allocate space.

As the tool is explored further, Alfano believes it could

editor@tunnelsonline.info

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



Jon Young
Editor



be used to practice complex tasks, maintenance or repairs for machines that have run into trouble in the field. The environment could be manipulated to determine the minimum space needed around a TBM to perform an unexpected operation. It could also be used to rehearse the assembly and dismantling of machines in confined space.

The tool also allows the user to place avatars into the model to undertake tasks. They can be manipulated to perform routine maintenance allowing the user to see where the hazards or challenges might be when performed in real life.

This leap forward in 3D technology, which was pioneered for the automotive sector, offers a small window into the future of machine tunnelling.

It is easy to imagine an augmented reality headset being donned by a machine operator and the full workings of the TBM being visible to the crew.

Or in a further leap, this kind of system might one day remove men from the tunnel environment entirely and have them operate the machine from a small dark room, perhaps somewhere in Schwanau, Germany

This month...

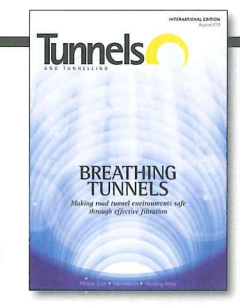
20 YEARS AGO

James Blake, secretary of works for the Hong Kong Government authors the foreword to a special supplement on tunnelling in the Pacific Rim. Among other projects he highlights is the Airport Core Programme to be funded by government direct expenditure. Of particular interest to readers will be the tunnels for these airport-related contracts: the people mover at the airport itself; through the bedrock of Tsing Yi Island and the dual three-lane expressway. Hong Kong is building for the future. Some USD 4bn of work is underway with USD 10bn still in the pipeline, and construction experience and technological improvement is happening all the time.
Tunnels and Tunnelling Pacific Rim Issue, August 1993, p.5

40 YEARS AGO

Work has just begun on the FRF 315, 12,720m-long Fréjus road tunnel following the Franco-Italian agreement signed last year. When completed in five years time, it will provide the most direct route across the Alps between Lyons and Turin. Both entrances to the tunnel will be reached by three-lane roads with a maximum gradient of five per cent and a minimum radius of 400m on bends, permitting a basic speed of 100kph. The French portal is at an altitude of 1,228m while the Italian is 1,297m. The height of the tunnel will be 4.5m to allow passage for vehicles up to 4.1m tall. A reconnaissance gallery has determined that the calcareous schist bears no water.
Tunnels and Tunnelling, September 1973, p.13

Cover
Particulate matter in road tunnels is a serious health concern if not properly filtered and ventilated



Next issue

In honour of the 150th anniversary of the opening of the London Underground, Tunnels will be publishing an (abridged) history of the epoch-spanning project. Its legacy to cities all over the world is plain, but it is easy to forget the decades of financial neglect

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DELHI METRO: 8 EPBMs FOR THE PHASE III

TERRATEC is delivering a total of eight EPB Tunnel Boring Machines to four different projects of the new Phase III of Delhi Metro.

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TUNNELLING SOLUTIONS | METRO



The Salmankas tunnel project, p.30



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A personal account of a tunnel fire test scenario gone wrong, with stark warnings for analysts, designers and anyone to take smoke seriously

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David Clayton, Morgan Sindall
The second part of the 2013 Harding Prize winning paper. The author revisits the Lee Tunnel

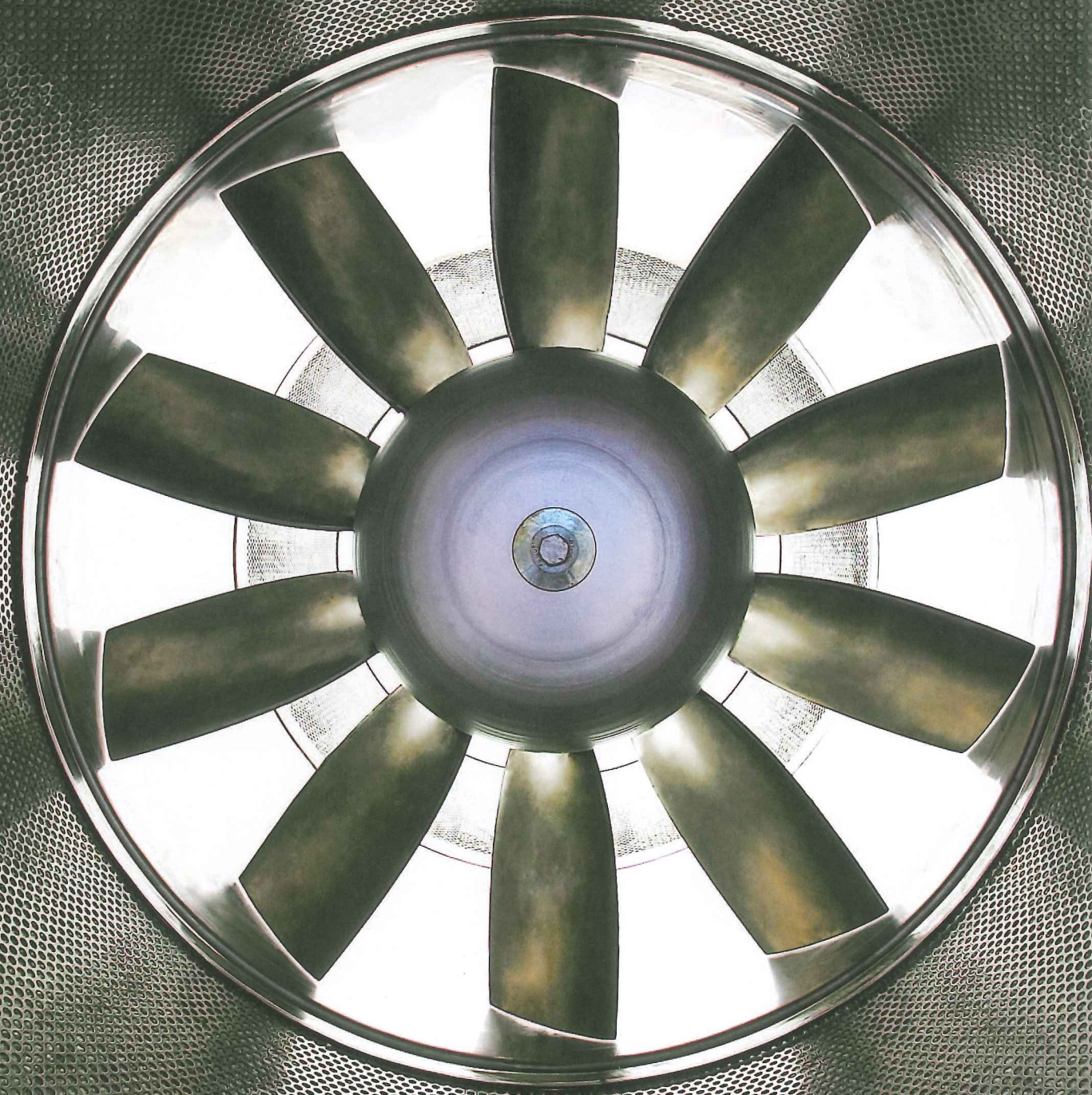
Contributors

David Clayton
David is the 2013 winner of the BTS Harding Prize. The now annual prize is awarded to the best paper submitted by a young tunnel engineer. David is currently a Morgan Sindall design engineer for temporary and permanent works on the Lee Tunnel sewerage project in London, UK



Petr Pospisil
Petr is an associate of consultancy company Tunnelventilation.pro. He has over 20 years of experience in plant engineering, tunnel engineering and tunnel safety. In this issue of *Tunnels*, he can be read on page 41 presenting an account of an earlier ventilation test scenario





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News briefs

ITALY

Breakthrough on the second bore of the Val Sarentino road tunnel project in northern Italy was due to take place on 19 July as *Tunnels* went to press.

ITALY

The first parts of the 15m diameter, NFM TBM ordered to bore the twin 3.9km tubes of the Caltanissetta road tunnel arrived at site last month as *Tunnels* went to press. The tunnel is part of the refurbishment of a 28km section of highway in the Caltanissetta and Enna provinces of Sicily, Italy.

SAUDI ARABIA

Parsons Brinckerhoff has been awarded the USD 93M role of program management office consultant by the Development Commission of Makkah and Mashaer on the Makkah Public Transport Program. The public transport program in Makkah is a plan for an integrated system which covers all means of public transport (metro lines, express bus lines, local buses, and shuttle buses). The project in Makkah includes a network of trains consisting of four metro lines, with total lengths of 114km and 62 stations.

London Bank upgrade awarded

Great Britain Transport for London's (TfL) Board has approved the funding to award a contract to Dragados SA, through the new Innovative Contractor Engagement (ICE) process for the Bank station capacity upgrade project, it was announced last month.

TfL has notified all contract bidders of the process' outcome.

The Bank and Monument

LONDON PLANS NEXT MEGA PROJECT

Great Britain London could play host to another tunnelling megaproject following a GBP 30bn (USD 45.4bn) proposal earlier this week. The Roads Taskforce, commissioned by Mayor Boris Johnson, put forward a '20-year vision' for portions of the North and South Circular roads to be placed underground.

If implemented, the scheme would be aimed at making surface space greener and more pleasant, rather than being aimed at increasing road capacity. A total of 19 projects were outlined in the proposal.

Transport commissioner for London Peter Hendy said, "We welcome the task force's vision [...] We'll now work with partners, including

London's boroughs, to turn this vision into reality."

Caroline Pidgeon, one of two Liberal Democrat members of the London Assembly said, "The whole idea that you can tunnel around London, I think, is going back to the 1980s, thinking we can build huge urban motorways through London.

"It doesn't make sense and it won't add up. It's a £30bn estimate, but I'm sure it will cost at least double that, and the reality is we'll lose homes around these roads and so on."

The full report can be downloaded here: www.tfl.gov.uk/corporate/projectsandschemes/28187.aspx

Tube station complex is located in the heart of the City of London financial district and is the fourth busiest interchange station on the Underground network with 96,000 customers during the morning rush hours, which is set to increase. It is a key interchange served by six lines.

The upgrade project will, by 2021, deliver increased capacity at Bank station and a step free route between the Northern line platforms, Docklands Light Rail and street levels.

David Waboso, London Underground's capital programmes director said: "We used the new ICE procurement process for the first time with this project. The process has been designed to allow bidders to bring their expertise and knowledge to drive innovation that will reduce cost and risk to the project.

"We're delighted with the outcome and market response to our innovative procurement model that meets the mayoral and governmental imperative to deliver better value for money and public spending.

"The lead bidder represents both the lowest bid price and offers the greatest benefits."

Korea pledges millions of dollars for Malakand tunnel

Pakistan The South Korean government has pledged USD 78M for construction of the tunnel through the Economic Development Cooperation Fund, Pakistan's National Highway Authority (NHA) announced to the nation's press last month.

The 9.7km project includes three bridges and approach roads on both sides of the tunnel.

The NHA will build the Malakand tunnel to shorten distance for travellers in the Dir, Malakand, Swat and adjacent areas. It will provide Pakistan with easy access to Central Asian states.

Chunil, a Korean company, prepared the feasibility study for the tunnel, recommending Dargai as the starting point and Batkhela as end point of the tunnel.

Executive Committee of the National Economic Council (ECNEC) gave approval for the project in May 2011.

TBMs launch on Eglinton project

Canada The first pair of TBMs mining the Eglinton Crosstown LRT project in

Toronto launched on 5 June.

The machines will mine eastward from Black Creek Drive. A second pair of TBMs will dig from just west of Leslie Street heading west toward Yonge and Eglinton. The machines will bore a little more than 10km of LRT tunnel at a rate of approximately 10m to 15m a day.

The new LRT line will run about 19km along Eglinton Avenue and will include up to 25 stations. More than 10km, from approximately Keele Street to Laird Avenue, will be underground. The Eglinton Crosstown LRT is expected to be in service by 2020 and will create thousands of jobs.

"Our government is moving forward with the largest transit investment in a generation to get the region moving. The new Eglinton Crosstown LRT line will get commuters to work, school and play faster than ever before, up to 60 per cent faster than today," said Glen Murray, Minister of Transportation and Minister of Infrastructure.

The TBMs are named Dennis and Lea, for the Mount Dennis and Leaside neighbourhoods, and Don and Humber, representing the nearby rivers.

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Authorities shut down Mexican smuggling tunnel

USA US and Mexican authorities have shut down an incomplete cross-border drug smuggling tunnel following its discovery during a routine inspection of Arizona's main storm drain system. Investigators believe the tunnel, which was in the final stages of construction, would have exited on the US side through a public car park in the city.

While inspecting a storm drain, authorities found a concrete access panel embedded in the invert. Upon removing the panel, they located an illicit tunnel containing numerous tools, a core drill and forced air ventilation.

The passageway stretched for approximately 160ft (48.7m) and was roughly 2ft (0.6m) wide by 3ft (0.9m) tall. Some 153ft (46.6m) of the tunnel is located within the US, with some 7ft (2.1m) in Mexico.

A water line, storm drain and two fibre optic lines were exposed inside the passageway.

No people or drugs were found inside the tunnel and no arrests have yet been made in the case, which remained under investigation by the Nogales Tunnel Task Force at the time *Tunnels* was going to press.

Herrenknecht receives lifetime achievement award

Germany Martin Herrenknecht, chairman of the management board of Herrenknecht, has been awarded the prestigious Deutscher Gründerpreis 2013 in the category 'Life's Work'.

Herrenknecht received the award for outstanding entrepreneurs in Germany earlier this week at the ZDF television studios in Berlin.

Accepting the award at the ZDF television studios in Berlin, Herrenknecht said: "I

am very excited about this award. It honours my mother who believed in me from the beginning and equipped me with the necessary start-up capital. This award is just as much for my family, which has often been neglected by me and yet has always stood by me.

"And finally, the award honors the loyalty and hard work of my staff, who have made the company Herrenknecht a champion on the world market."

The Deutscher Gründerpreis is awarded each year to winners from five categories. Schools, Start ups, Climbers and Life's Work.

It recognises entrepreneurial role models whose companies are at various stages. The Deutscher Gründerpreis is awarded by Stern, Sparkassen, ZDF and also Porsche.

Pakistan and China sign mega tunnel deal

Pakistan/China China and Pakistan have signed eight agreements, including an USD 18bn deal to build a 200km-long tunnel.

The Pak-China Economic Corridor will link Pakistan's Gwadar Port on the Arabian Sea and Kashghar in Xinjiang in China's northwest region.

For the development of the Economic Corridor project, the two countries have agreed to collaborate on connectivity construction, people-to-people construction exchanges and exchanges between local governments and organisations, according to reports from local press.

Pakistan and China have become close diplomatic and military allies. While Pakistan prime minister Muhammad Nawaz Sharif, who is on his first foreign trip since his election in May of this year, will be looking to secure infrastructure projects in addition to the corridor to tackle a chronic energy crisis, and general financial and economic malaise in Pakistan.

CONTRACT TO BUILD AUSTRALIA'S LONGEST RAIL TUNNELS AWARDED

Australia Australia's New South Wales government announced last month that a JV made up of Thies, John Holland and Dragados (TJHD) has been selected to build a new underground rail system in Sydney.

The AUD 1.15bn (USD 1bn) North West Rail Link involves construction of twin 15km-long tunnels, the longest rail tunnels built so far in Australia. The project also includes civil works for five of the eight new stations and two service facilities.

Four custom-made TBMs will be used to construct the 6m diameter tunnels with the first of the TBMs to be in the ground by the end of next year.

Bruce Munro, Thies managing director said: "Thies has been delivering major projects in New South Wales for decades and between us, Thies and John Holland have built 70 per cent of Australia's major underground infrastructure over the last 10 years. Together we have more tunnelling experience in Sydney sandstone than any other contractor and when combined with the international expertise of Dragados, we will deliver a fantastic transport outcome for the people of northwest Sydney."

TJHD expects to place orders for the TBM this summer. Work will start shortly to prepare the three major tunnelling sites at Bella Vista, Showground and Cherrybrook with contract completion scheduled for first quarter 2017.

Market debut for new raise borer

Australia Equipment manufacturer Terratec has launched a new rig to join its raise boring product line.

The machine, called the Universal Boxhole Boring Machine - UB1000, is designed to boxhole sections up to 1.06m diameter and 100m long. It can also ream conventional raises nominally 1.8m diameter by 200m deep.

Terratec spokesman Kit Lau argued, "The machine brings into the market innovative solutions to allow the safe and efficient execution of slots in the mines with a fully automated raise drill.

"The Derrick Assembly, including the gearbox complete with floating drive box (Chuck), is suitable for 10in diameter by 48in [1.2m] long drill string.

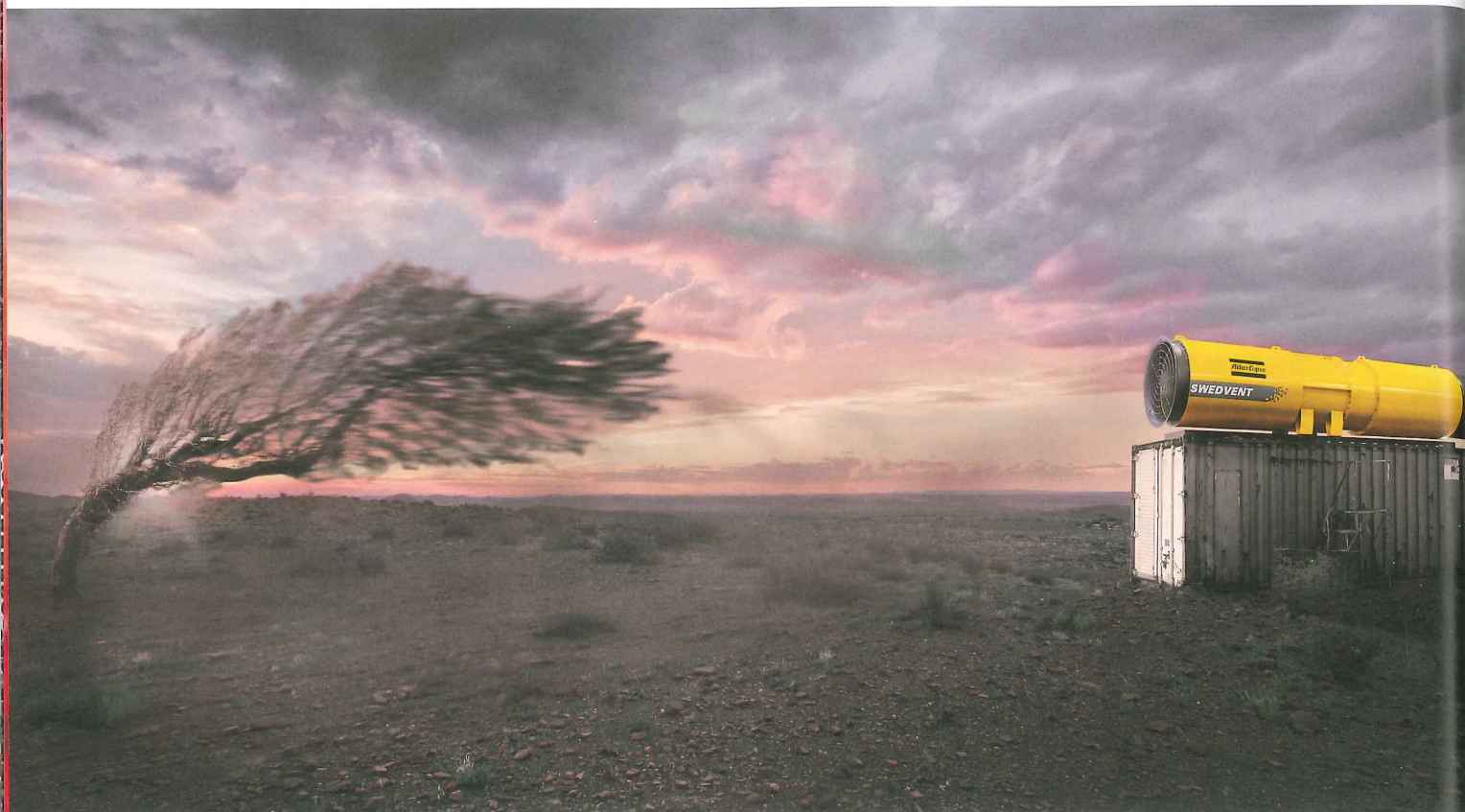
"The gearbox is designed so it can be positioned with the drive box pointing up for box-holes, or down for conventional raising."

The machine is supplied complete with a gearbox turning cradle suitable to quickly and easily index from box hole mode to raise-bore mode in less than one shift. The integrated torque column/thrust cylinders provide balanced thrust and clear access from all sides.

The rig is able to operate at up to 45 degree dip, either side of centre-line, in a 'cross-drift' orientation, with no requirement to turn the rig first, or any modifications to change from left hand to right hand dip.

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Contract awarded for Finnish underground station

Finland YIT Construction and Länsimetro have been awarded a contract for the Otaniemi station for the West Metro in Espoo, Finland, YIT announced last month.

The total value of the contract is EUR 29.4M (USD 38.3M). The contract covers the construction of the Otaniemi station building, including its outdoor areas, a technical shaft, the underground tunnel station and service tunnels.

The construction of the station was slated to start last month as *Tunnels* went to press, and is to be completed in September 2015.

The aim is that all West Metro stations will be opened at the same time at the end of 2015, YIT stated.

"We can extensively utilise our expertise in facilities and infrastructure in the construction of the Otaniemi metro station," said Anne Piiparinen, director of the construction engineering unit of YIT.

"Demanding contracts emphasise the diverse competence of our personnel so that we can flexibly utilise our resources and operating models at various work stages. We have already successfully applied our expertise to, for example, the construction of the Ring Road stations."

Brazil to invest USD 22bn in transit

Brazil Brazil will spend USD 22bn to upgrade its public transit systems, the president announced last month. The spending would largely be invested in metro work.

Brazilian president Dilma Rousseff promised the funding alongside proposals to reduce corruption in the country's political system.

The announcements come amid millions-strong protests that sprang up last month from public anger at high

transport fares, poor public services, state corruption and the cost of hosting the 2014 Fifa World Cup.

Brazil's second largest city, Rio de Janeiro, has also been selected as the host city for the 2016 summer Olympic and Paralympic games.

Local media-owned polling institute Datafolha reported 27 per cent of protestors were marching for a better transport system.

Prior to the protests, former president of the Brazilian Tunnelling Committee Tarcisio Celestino told *Tunnels* that annual metro ridership figure increases have been artificially low, as they are constrained firstly by the pace of capacity expansion.

TBM Victoria breaks through at Canary Wharf station

Great Britain Herrenknecht TBM Victoria has joined sister TBM Elizabeth in Canary Wharf box, after successfully breaking through in June on the Crossrail project in London, UK.

Both machines will now undergo maintenance inside the Canary Wharf station box before being moved through to resume tunnelling towards central London.

The eastern tunnelling machines were launched from

the Limmo site near Canning Town towards the end of last year to create 5.16 miles (8.3km) of tunnels from east London to Farringdon. These drives are Crossrail's longest tunnel section.

A marathon-equivalent 26 mile (42km) section of tunnels beneath London will be built in total for Crossrail.

The final machine for Crossrail is being readied for factory acceptance in Herrenknecht's manufacturing plant in Schwanau, Germany.

UK PM announces initiative to create 100,000 engineering technicians

Great Britain Prime Minister David Cameron last month announced a new scheme that aims to produce an additional 100,000 engineering technicians by the year 2018.

The multi-million pound initiative is a national drive to encourage young people to sign up to an engineering apprenticeship.

The scheme aims to create a whole new generation of engineering technicians, giving them structured on-the-job training built upon a recognised academic qualification.

Working through new and established apprentice

schemes, the initiative has been created by the Institution of Mechanical Engineers (IME), the Institute of Civil Engineers, the Institution of Engineering and Technology and is backed by the Gatsby Foundation.

The Prime Minister made the announcement as the Bloodhound Supersonic Car visited Downing Street, along with a number of existing engineering apprentices and school children.

Cameron said: "British engineering and innovation are a part of our history that we are rightly very proud of and our engineering excellence continues to change the world that we live in for the better. Bloodhound is a fantastic example of what our engineers can achieve."

He added, "Apprenticeships are at the heart of our mission to rebuild the economy, giving young people the chance to learn a trade and to build their careers, creating a truly world-class, high-skilled workforce that can compete and thrive in the global race."

Stephen Tetlow, chief executive of the IME said: "To help UK companies succeed in this ever-growing competitive global marketplace we need the people with the highest professional skills."

HS2 MAY COST BILLIONS MORE THAN PLANNED

Great Britain The proposed budget for the HS2 railway has risen by nearly GBP 10bn (USD 15.2bn) to more than GBP 40bn (USD 61.1bn), the UK transport minister has announced. The new budget took account of design and environmental changes, including alterations to the route such as a tunnel under the M6 near Birmingham, UK.

Speaking in the House of Commons, Patrick McLoughlin said the new projected cost included 'contingency' money. The first phase budget is now GBP 21.4bn (USD 32.7bn), with GBP 21.2bn (USD 32.4bn) for phase two.

These figures include a contingency fund of GBP 14.4bn (USD 22bn) across the scheme, McLoughlin announced.

Alison Munro, chief executive of client HS2, said the cost rise provided "a clear mandate not only to deliver the infrastructure, but also to work with the towns and cities to create a true engine for growth. The target we have been set is consistent with our baseline three estimate produced in May and upon which Department for Transport spending review bid was made. The scope of which is the same as the current round of consultation."

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TUTOR PERINI TO BUILD BOX TUNNEL

USA Amtrak awarded a USD 133M contract to Tutor Perini to construct an underground concrete casing beneath the Eastern Rail Yard of the Hudson Yards site in New York City.

Some USD 185M in funding has been secured to build a tunnel box that will preserve the right-of-way for new flood-resistant tunnels under the Hudson River. The funds will go towards an 800ft (244m) long concrete casement, or tunnel box, that will preserve the right-of-way for the two new flood-resistant tunnels into Manhattan's Penn Station.

The box tunnel will measure approximately 800ft (244m) long, 50ft (15m) wide, and 35ft (11m) tall, and will

extend underground from 10th Avenue to 11th Avenue between 31st and 33rd Streets. Construction is expected to begin in August 2013 and substantial completion is expected in late 2014.

Ray LaHood, US Transportation Secretary, said: "The federal funding announced [last month] makes it possible for Amtrak to begin construction this summer on a project to preserve a pathway for two new rail tunnels into New York that are critical for the future mobility and economic growth of the entire Northeast region. This project to build a concrete casing through the Hudson Yards commercial development property will protect the only viable right-

of-way for connecting the tunnels to the existing tracks and platforms at Penn Station, New York.

The new tunnels are one element of the Amtrak Gateway Program to increase rail infrastructure capacity between Newark, New Jersey, and Penn Station, New York. By eliminating this bottleneck into New York, which is the Northeast Corridor's most congested segment, the Gateway Program will increase resiliency against severe weather events, add redundancy and reliability for Amtrak and New Jersey Transit's shared operations, and provide additional capacity for the future increases in commuter, intercity and high-speed rail service.

Northgate tunnel bids opened

USA A Jay Dee-led joint venture submitted the lowest bid out of six teams for the Northgate Link light rail extension project in Seattle. Sound Transit opened the bids on May 30.

The contract is for 3.4 miles (5.5km) of twin light rail tunnels between Husky Stadium at the University of Washington and the Northgate Mall area in Seattle, as well as excavating the underground stations in the Roosevelt and U District neighborhoods. The engineer's estimate for the work was USD 595M. The six bids ranged from USD 440M to USD 517M.

JCM Northlink LLC, is a joint venture formed by Jay Dee Contractors of Livonia, Michigan; Frank Collucio Construction Company of Seattle; and Michaels Corporation of Brownsville, Wisconsin. JCM recently completed work mining the light rail tunnels between downtown Seattle and Capitol Hill Station as part of the University Link project.

"We are very pleased with the competitive response from the contracting community on this important contract for the Agency that could save taxpayers

millions of dollars," said Ahmad Fazel, Sound Transit executive director of design, engineering and construction management.

Sound Transit will now evaluate the bids to determine the lowest responsive and responsible bidder. Staff will bring a recommendation to the Sound Transit Board to approve awarding the contract this summer. This contract is the largest single piece of work on the USD 2.1bn Northgate Link Extension project.

Last month, losing bidder Traylor Frontier-Kemper has, according to local papers, asked Sound Transit to rebid the project after its bid was rejected due to some confusion in the process. Sound Transit is reviewing the situation.

The winning contractor will launch two TBMs from the Roosevelt Station site to excavate the tunnels to the U District Station and on to the University of Washington Station at Husky Stadium. A third TBM will be launched from the Maple Leaf Portal near NE 94th Street and will bore two tunnels, to the Roosevelt station.

The work is scheduled to begin late this year and last just over four years.

Different Sound Transit

contractors began preparing the Roosevelt Station site last summer and recently began demolition of existing buildings at the U District station site.

The Northgate Link project is scheduled to open in 2021 and will connect with the University Link tunnels to downtown Seattle. The University Link section is scheduled to open in 2016.

UK Government supports economic growth for the construction industry

Great Britain Reforms to strip out inefficiencies in public sector construction generated GBP 447M (USD 682.6M) in savings for the taxpayer last year and will deliver up to 20 per cent savings in project costs by 2015, Cabinet Office Minister Chloe Smith said.

Making links across departments has meant Government is able to act as a single customer to the construction industry and provide clear benchmarks for budgets by setting out the average price it expects to pay for projects. The new set of benchmarks aims to drive down project costs further and encourage the industry to offer more competitive and innovative solutions.

Speaking at the annual

Government Construction Summit attended by suppliers, contractors and those responsible for public sector construction projects, Chloe Smith said: "Government is a good client who pays on time and invests in projects that make an important economic impact to help the UK compete in the global race. We've always been ambitious in our plans to reform public sector construction, and the GBP 447M (USD 675M) in savings generated by acting as a single customer shows just how we are spending public money more intelligently.

"Working more collaboratively has identified where we can strip out unnecessary waste in construction projects and test out innovative models to help businesses of all sizes win Government contracts. Our reforms aim to deliver projects up to 20 per cent cheaper by 2015 - making at least GBP 1.2bn [USD 1.8bn] available to reinvest."

Alasdair Reisner, Civil Engineering Contractors Association (CECA) director of external affairs, said: "Two years ago, industry and government agreed to work together to drive the cost of construction down by 20 per cent. We have welcomed the chance to be

STATE OF COLORADO - DEPARTMENT OF TRANSPORTATION REQUEST FOR LETTERS OF INTEREST FOR DESIGN BUILD SERVICES

Eisenhower/Johnson Memorial Tunnel Fixed Fire Suppression System

The Colorado Department of Transportation (CDOT) is soliciting Letters of Interest to retrofit the Eisenhower/Johnson Memorial Tunnel (EJMT) with a Fixed Fire Suppression System (FFSS). The facility exists on a major commercial corridor for interstate commerce with an Average Annual Daily Traffic (AADT) of approximately 30,000 vehicles per day, equating to over ten million vehicles per year. CDOT is seeking a non-programmatic categorical exclusion (CE) for this project.

The goals of this project include: Provide a system with the greatest flexibility in suppressing different fires; maintain compatibility with existing tunnel operations and minimize complications with future maintenance; maximize safety of workers and traveling public; minimize project delivery time. The notable constraints regarding this project include: The new system shall be compatible with the climatic factors present at the EJMT; construction cannot impact the peak period traffic capacity; the new system shall be constructed in conformance with the U.S. Forest Service easement documents.

All companies or teams submitting a Letter of Interest are invited to attend an optional information meeting on August 21, 2013, at 10 a.m. in the CDOT Headquarters Auditorium located at 4201 E. Arkansas Avenue, 2nd Floor, Denver, CO 80222.

The Letter of Interest must be sent by registered mail, Federal Express, UPS or a similar delivery method that furnishes proof of having been received by CDOT no later than 2:00 p.m. on September 12, 2013. Any Letter of Interest sent via fax or email will not be accepted.

Please address the Letter of Interest to: Stephen Harelson, P.E. EJMT FFSS, Resident Engineer CDOT Region 1, West Engineering Section 425A Corporate Circle Golden, CO 80401

The Letter of Interest submittal must include the title (Statement of Interest for the EJMT FFSS), submitting company or team name, the contact person's name, address, phone, fax, and email information. If your firm is a Disadvantaged Business Enterprise or Emerging Small Business, please identify your firm as such and state all local agencies with whom you are certified. Letters of Interest will also be used to compile a list of interested companies for any notices and announcements relating to this project. Additional information can be found on the project website <http://www.coloradodot.info/projects/Eisenhowerfiresystem>



- Locomotives, Unloaders for Gallery, Personnel Carrier, Remixer
- Gallery Railway Equipment and Accessories
- High performance Dumpers
- Underground Ventilation, spiral and flexible Ventilation Ducts
- Mortar Injection Pumps
- Rock-Bolts, Friction Anchors, Self-drilling Injection Anchors
- Pipe Roof Systems
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- Polyurethane resins and Injection Pumps

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involved with this work, and are pleased to see that the results are starting to emerge, producing sustainable savings that reduce the cost of construction for the taxpayer. We hope that the new approaches will be adopted widely, creating a leaner and more competitive industry that delivers exemplary results for its customers."

Don Ward, CEO of Constructing Excellence, added: "The early findings of the trial projects monitored by Constructing Excellence already point to smarter procurement delivering significant improvements in value for money for the public purse."

"Of course it is key to ensure savings do not impact on safety, quality or whole life performance, and our monitoring will focus on this and capital savings."

Costain bags TfL deal

Great Britain Costain has announced that it has been awarded one of four places on Transport for London's (TfL's) framework for Early Contractor Involvement (ECI) and Construction, initially worth approximately GBP 200M (USD 312M). The projects involve bridge and tunnel strengthening in the capital city.

The group is working on its first project within this framework, the Hammersmith Flyover project, worth approximately GBP 60M (USD 93.7M). Andrew Wylie, Chief Executive of Costain, said: "Costain is delighted to gain a place on TfL's framework, and to commence work on the Hammersmith Flyover which is a technically challenging structure and an important part of London's infrastructure."

"This award further enhances Costain's reputation for innovation and engineering expertise across the whole life cycle of an infrastructure asset, as well as our recognised commitment to providing our customers

with certainty of delivery and cost within a collaborative working approach."

Crystal Financial Agents USD 57.1M facility for the Robbins Company

USA Independent commercial finance company, Crystal Financial LLC, announced early last month the closing of a USD 57.1M Senior Term Loan for The Robbins Company.

Proceeds from the new financing replaced the company's existing debts and provided incremental liquidity to fund their continued growth. The four-year facility will mature in May 2017.

"The Company's long-standing history, the leadership position, and the market reputation their products have clearly demonstrated their unique and defensible market position. Throughout the process, we were very impressed with the company. Lok Home and his team have built Robbins into a global leader for excavating machinery in the tunnelling sector. We are very excited to be working in partnership with them and providing financing to support such an outstanding company and management's business plan," said Andrew Hettinger, managing director at Crystal Financial.

Mansky tunnelling completes

Russia Tunnelling has been completed on the 2.5km Mansky Railway Tunnel. Contractor SK Most undertook work in the Krasnoyarsk Region in central Russia over a period of approximately 18 months.

The work to cut through the rocky foothills of the Sayan Mountains was executed by a Lovat TBM.

An SK spokesman said, "Construction of the new Mansky tunnel began in 2005. The preparation phase lasted for the first two years.

SECOND MT VICTORIA TUNNEL PLAN UNVEILED

New Zealand A second two-lane tunnel through Mount Victoria could be open to traffic within a decade, NZ Transport Authority announced. The agency has planned a second tunnel and widening of Ruahine Street and Wellington Road to connect to the new NZD 90M (USD 72M) Basin flyover.

The plans for the second tunnel show it would sit directly along the northern side of the existing tunnel. It would provide two lanes for eastbound traffic, along with a separate pedestrian and cycle facility linking to the flyover. On the Hataitai side of the tunnel, Ruahine Street will become four lanes, and will also sport a pedestrian and cycling path.

Heading towards the airport Wellington Road will be widened to six lanes and traffic lights will be installed at the intersection with Ruahine Street.

"Currently, traffic along Ruahine Street moves at a snail's pace during peak hour and there isn't much provision for pedestrians and cyclists. Doubling the capacity of Ruahine Street, putting in a new facility for people travelling on foot or by bike, and linking it all to a second Mount Victoria Tunnel will make a world of difference to everyday travel," said Jenny Chetwynd, regional director, NZ Transport Agency.

The transport agency plans to seek resource consent late next year, with an aim to building the roading projects between 2018 and 2022.

The projects are all part of a NZD 800M (USD 641M) improvement project from Ngauranga to the airport, and the announcement sits alongside new details about the flyover project and a the reveal of a major public transport study for Wellington.

A service and drainage gallery was driven in 2007-2010.

"The driving of the new 2,464.8m-long tunnel began in October 2011. The tunnelling was carried out under complex geological conditions, in the rocks with a strength ranging from f=16 to f=20 on the Protodyakonov scale."

The TBM was driving about 10m a day and about 200m a month on average.

Despite the challenging conditions, the connection has been made with high precision and no deviations from the design route were recorded.

The engineers are prepared to have the new tunnel commissioned in June 2014. A non-ballasted track, utility lines and contact network were yet to be put in place as Tunnels went to press.

Also still to be completed were the railway approaches to the tunnel, and installation of the permanent lining in the connections of the tunnel to the gallery.

The spokesman concluded that "the New Mansky Tunnel is of strategic importance for expanding railway traffic along the southern leg of the Krasnoyarsk Railway."

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



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Share tracker			
Company	May	June	Change (%)
Aecom (NYSE: ACM)	30.46	30.1	▼ 0.36 (1.18)
Atkins (LSE: ATK)	882	864.5	▼ 17.5 (1.98)
Balfour Beatty (LSE: BBY)	214.4	218.7	▲ 4.3 (2.01)
BASF Global (XETRA: BAS)	73.55	72.87	▼ 0.68 (0.92)
Bekaert (BSE: BEKB)	21.5	22.98	▲ 1.48 (6.88)
Bilfinger Berger (DUS: GBF)	76.22	77.06	▲ 0.84 (1.10)
Caterpillar (NYSE: CAT)	88.19	83.21	▼ 4.98 (5.64)
Costain Group (LSE: COST)	276.25	255.25	▼ 21 (7.60)
Ferrovial (MCE: FER)	13.15	12.27	▼ 0.88 (6.69)
Hindustan Construction Company (BOM: HCC)	14.15	11.2	▼ 2.95 (20.84)
Hochtief (XETRA: HOT)	57.5	49.5	▼ 8 (13.91)
Morgan Sindall (LSE: MGNS)	545	582	▲ 37 (6.79)
Sandvik (STO: SAND)	94.05	86.95	▼ 7.1 (7.55)
Shanghai Tunnel Engineering (SHA: 600820)	8.92	8.63	▼ 0.29 (3.25)
Strabag (LSE: STR)	17.96	16.85	▼ 1.11 (6.18)
URS Corporation (NYSE: URS)	45.67	46.7	▲ 1.03 (2.26)
Vinci (EPA: DG)	37.64	38.66	▲ 1.02 (2.71)

Prices are taken on the 12th of each month. NYSE is in USD. LSE is in GBP. STO is in SEK. BSE, EPA, MCE, STR and XETRA are in EUR. BOM is in INR. SHA is in CNY.

Central bank rates	
	Rate (%)
AUD	3.00
BRL	8.50
CAD	1.00
CHF	0.25
CNY	6.00
EUR	0.75
GBP	0.50
INR	7.50
JPY	0.10
NZD	2.50
USD	0.25

Rates are taken on the 12th of each month.

Parsons has announced it has opened a new office space in Dubai, UAE. The new office was opened to accommodate the technical staff required to support recent contract awards, particularly the design process of many projects in Dubai, the company stated.

"We are excited to continue growing our Middle East operations to meet our customers' needs," said Guy Mehula, Parsons MENA President.

"At present, we have more than 3,300 employees working from six offices throughout the MENA region, and this number continues to grow.

local British Columbian and Canadian market. Our local clients have already expressed their gratitude at seeing our on-the-ground presence for face-to-face meetings on short notice, and the timely delivery of services."

Parsons opens new office in Dubai

UAE Engineering and construction company

Oil price



Values are taken on 12th of each month.

New transatlantic joint venture

Canada/Italy Canada-based Delcan, and Italy-based Geodata announced a JV partnership to undertake services for tunnel and underground infrastructure projects in North America, Delcan stated last month.

Delcan stated that companies are well positioned to carry out the development, evaluation, preliminary and final design, and project and construction management of tunnels and related underground infrastructure.

"We are very excited to announce this joint venture of Delcan and Geodata, which brings together specialised expertise to better serve clients in the tunneling and underground infrastructure industry," said Joanne McCall, Delcan division vice president.

"With each company having unique expertise in the tunneling industry, this collaboration means that we can offer a wide scope of value added services to meet our client's growing needs."

Jacobs Associates expands Vancouver office

Canada Jacobs Associates has opened a larger office with locally based staff dedicated to British Columbian (BC) projects. The expansion will help the firm better provide tunnel and underground engineering for hydroelectric, mining, water supply, wastewater, rail, highway, and other transportation projects in the BC and the Western Canadian market, the company announced.

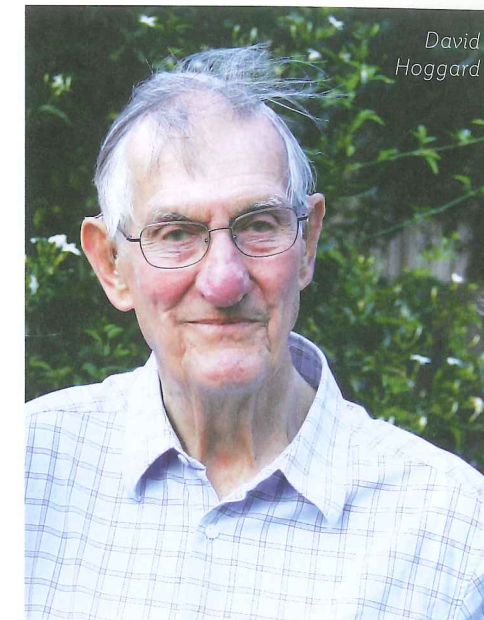
Associate Peter Raleigh and Staff Engineer Stephanie Fekete will be relocating to Vancouver and joining lead associate Dean Brox to support the expansion, the company said.

Recently hired staff engineer, Jose Aguilar, and project engineer, Katerina Sakarova, will also be joining the Vancouver team.

Brox, who helped establish the Vancouver office in November 2011, said: "Vancouver is a great city for Jacobs Associates to establish a new office in and serve the

DAVID HOGGARD

David Hoggard died on 30 April 2013. His colleague and friend Chris Parker remembers the man



David Hoggard

DAVID WAS that special combination of a naturally civilised, considerate and principled person, who chose to operate in a profession that was frequently exciting and often pretty uncivilised. It was challenging enough to be in construction above ground between 1955 and 1985, but to be tunnelling at that time was a somewhat bigger challenge altogether.

Meeting him on one of his contracts, there was never any doubt about who was in charge, even though in the tunnelling world there were always big characters who were difficult to control. David had a natural authority that could be tough when necessary. Yet away from the action he dealt with his staff and his foremen with a natural empathy and respect, and automatically and so easily gave them the support and direction they needed.

In a highly competitive construction industry, where management structures were constantly being revised, where contracts rode a knife-edge between profit and loss, where crises could suddenly demand decisive action and a cool head, these things never seemed to phase him. He handled the stress confidently and firmly, never losing his personality or compromising his innately high personal standards.

In the days when he was running tunnel sites, colleagues seldom remember him raising his voice, and that was in an environment where there could be lots of shouting. As project manager, his men, the tough and formidable tunnel foremen who put the miners to work, and who ran the black gangs of fitters who kept the tunnelling plant working all seemed to have a special regard for him. These men were big names in the tunnelling world in their own right.

David had grown up with them in the business, I suppose, as a junior engineer putting line and level on the tunnel face before the miners started building the next ring or sitting the time out with them in the decompression

locks. Then as a section engineer sorting out with them what plant and material they needed for the next shift. They knew him as one of them, and once he became the boss he had a natural and totally accepted authority over them which they didn't contest.

David came back from the second world war after a campaign with the Fleet Air Arm in the Far East flying missions off aircraft carriers as a very young man, which was probably a lot more exciting than he ever let on to us. He was I think something of a daredevil in his youth, who got a buzz from taking risk and could, when larking about, take your breath away. So clearly, volunteering for the Fleet Air Arm in wartime was very much in character.

David learned his engineering at Portsmouth for three years before joining Balfour Beatty. He was a tunneller from the start moving round the country on sewer and water tunnel projects, and the London Underground, learning the ropes and gaining experience and responsibility. When I first heard of him I was a young design engineer who had done his time in the design office and had to get out onto a construction site, and he was the project manager on the Second Blackwall tunnel and looking for engineers.

This contract was at the forefront of UK tunnelling at the time, and was probably the last contract in the UK to experience really high levels of compressed air. Men had to spend hours in decompression chambers after each shift, and in that environment, under threat of severe water ingress from the river, serious risk of fires in the compressed air and physical risks to the miners working the greathead shields and with shifts being worked 24 hours round the clock, David's responsibility as project manager was immense.

I didn't fancy the high levels of compressed air, so instead I went to the Dungeness B Nuclear Power Station contract. But when I wanted to come back to London it was David who gave me the chance second time round on

the Victoria Line contract from Victoria Station, which went south under the river to Vauxhall. David was now contracts manager for all BB tunnels which at the time included the Victoria Line tunnels through Kings Cross station.

He was responsible for constructing the concrete platform over Moorgate station in the City with its six above ground railway lines and its tube station on which now stand three multi-storey office blocks. He was responsible for taking the Jubilee Line through Bond Street station, which involved building a new station beneath Oxford Street which he had to totally close twice for long weekends. He was responsible for the outfall tunnel built in granite under the sea off Aberdeen. The list goes on.

For nearly twenty years David represented Balfour Beatty in the UK tunnelling world which comprised five companies with long histories in tunnelling going back to the 1920s. I remember the pride I felt going to meetings with these other tunnellers, or attending papers at the Tunnelling Society at the Institution of Civil Engineers, and hearing first hand the respect in which my boss was held in by the industry. He was very much regarded as one of the leaders of this rather exclusive and specialised profession.

But for me, above all, my memory of David is that he was always his own man. He could never be coerced into acting against his better judgement, and he always kept his personal independence even when it was tough to do so and required standing out against the crowd.

He was my boss and became my friend

ALDWYCH BATHS

Regeneration of a disused London Underground station is among 26 sites shortlisted for Forgotten Spaces 2013. The scheme organised by the Royal Institute of British Architects (RIBA) is an 'ideas competition' where entrants seek out redundant and neglected portions of London, UK and propose concepts for the re-use and adaptation of the locations.

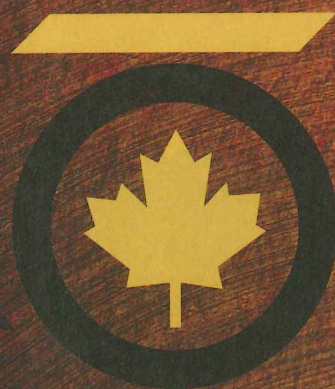
Aldwych Baths (pictured) was proposed by Charlotte Tamplin, Charlotte Marshall and Kate Stevens. It would make use of the disused Aldwych Tube Station which has been defunct since 1994.

The winning entry will be awarded GBP 5,000 (USD 7,450)



TAC AWARDS

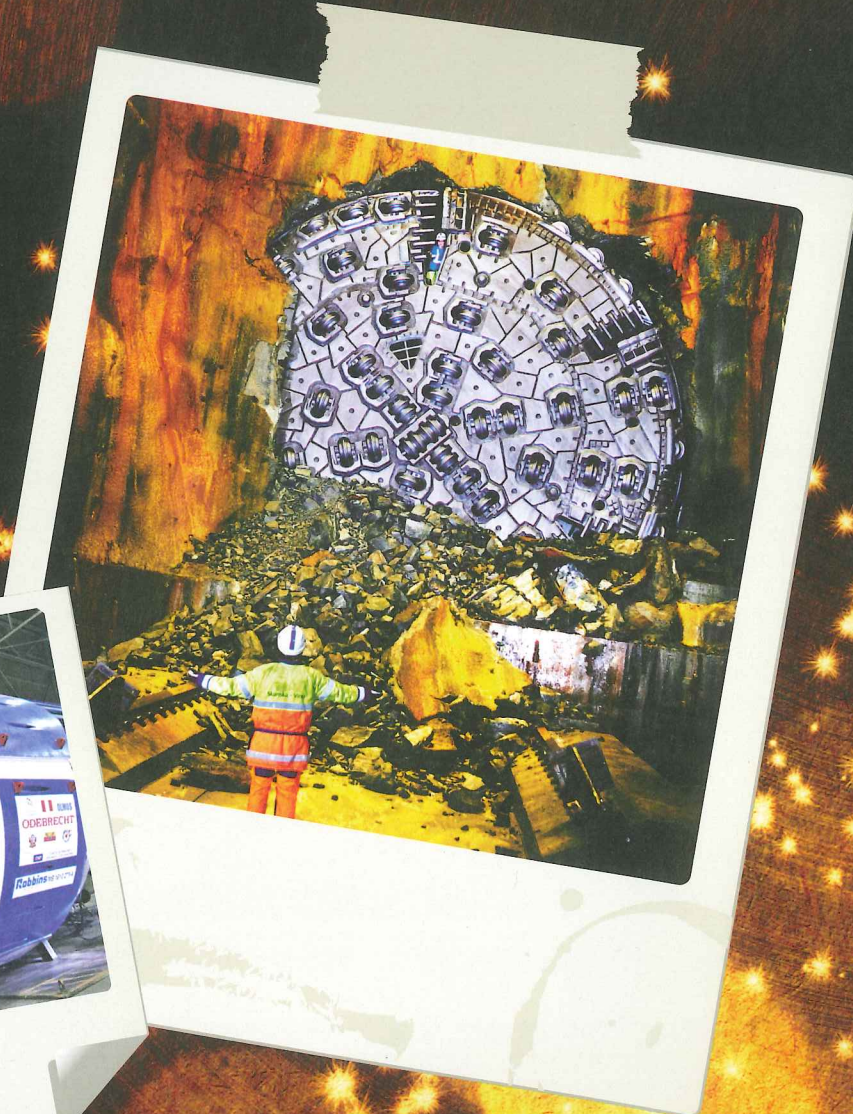
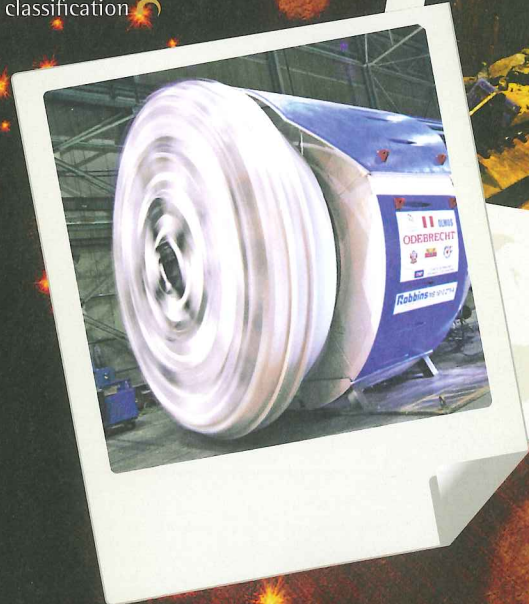
2013



ENTRIES ARE now being accepted for the Tunnelling Association of Canada's (TAC) 2013 Achievement Awards.

Tunnels is excited to partner with the TAC on the annual awards, which are presented each fall and recognize deserving individuals and projects in the Canadian and worldwide tunnelling sectors.

The 2013 TAC workshop, annual general meeting and 2013 awards will be held in Vancouver on November 15-16. This year's topic is Rock Tunnelling and will include international practitioners in the field, featuring Dr Nick Barton, who will present the background, development and application of the Q-system of rock mass classification.



The Awards

- Canadian Tunneller of the Year
- Canadian Project Award
- Worldwide Project Award

Nominations are to be submitted to the TAC National Office on or before September 1 by e-mail to awards@tunnelcanada.ca or by mail addressed to:

Tunnelling Association of Canada
8828 Pigott Rd
Richmond BC V7A 2C4

Visit www.tunnelcanada.ca/awards to download the required submission forms required, which can be filled in electronically or by hand. The nominee's resume must be submitted along with the completed form. Additional information may be sought if deemed necessary by the TAC Awards Committee.

Fall workshop

Rock Tunnelling Workshop
November 15-16
Sheraton Wall Centre Hotel, Vancouver, BC, Canada

This two day course will be of interest to those involved in tunnelling and underground mining and will address the following elements:

- Introduction to the Q-System of Rock Mass Characterization
- Tunnel Support Selection From Q Classification, and Support Element Properties
- Field Logging Practice: Logging - Rock Core and Rock Exposures, Q-Linkages Selection
- Mechanical Excavation: Principles of Rock Cutting, Logistics and Rock Support, Industry Innovations
- Drill and Blast Excavation - Blast Design, Blast Vibrations, Monitoring
- Health and Safety - Guide To Safety in Tunnelling in Canada
- Panel Discussion - Geology, Design, Risk and Safety

At the end of day one, attendees will be invited to join us that evening for the presentation of the 1st Annual Tunnelling Association of Canada Awards. Look for more information, including complete workshop details and registration pricing, on the TAC website at www.tunnelcanada.ca in July.

Please contact the Tunnelling Association of Canada office for sponsorship and trade exhibition opportunities.

Special room rates have been arranged at the Sheraton Wall Centre of CAD 150 per night.



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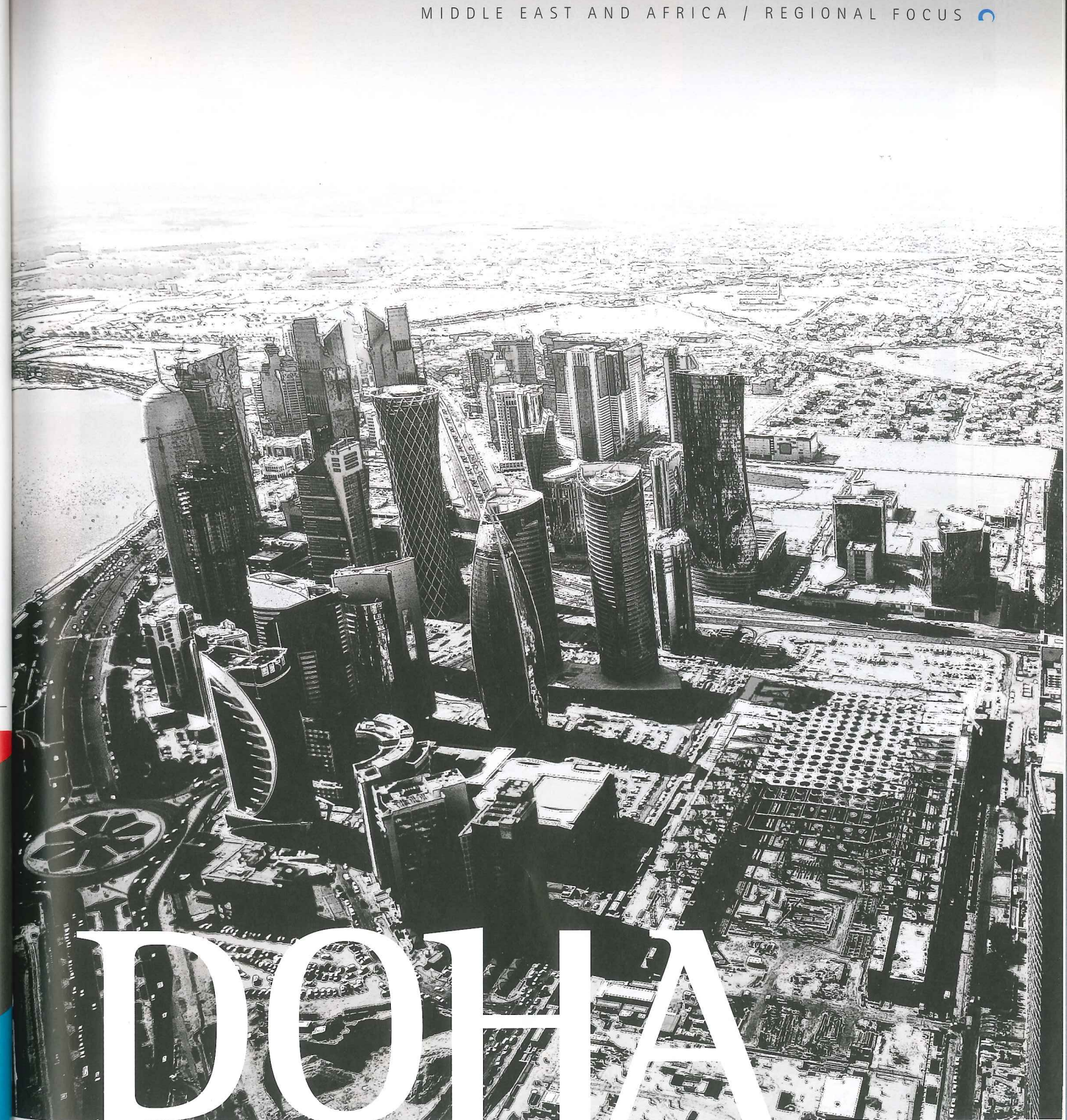
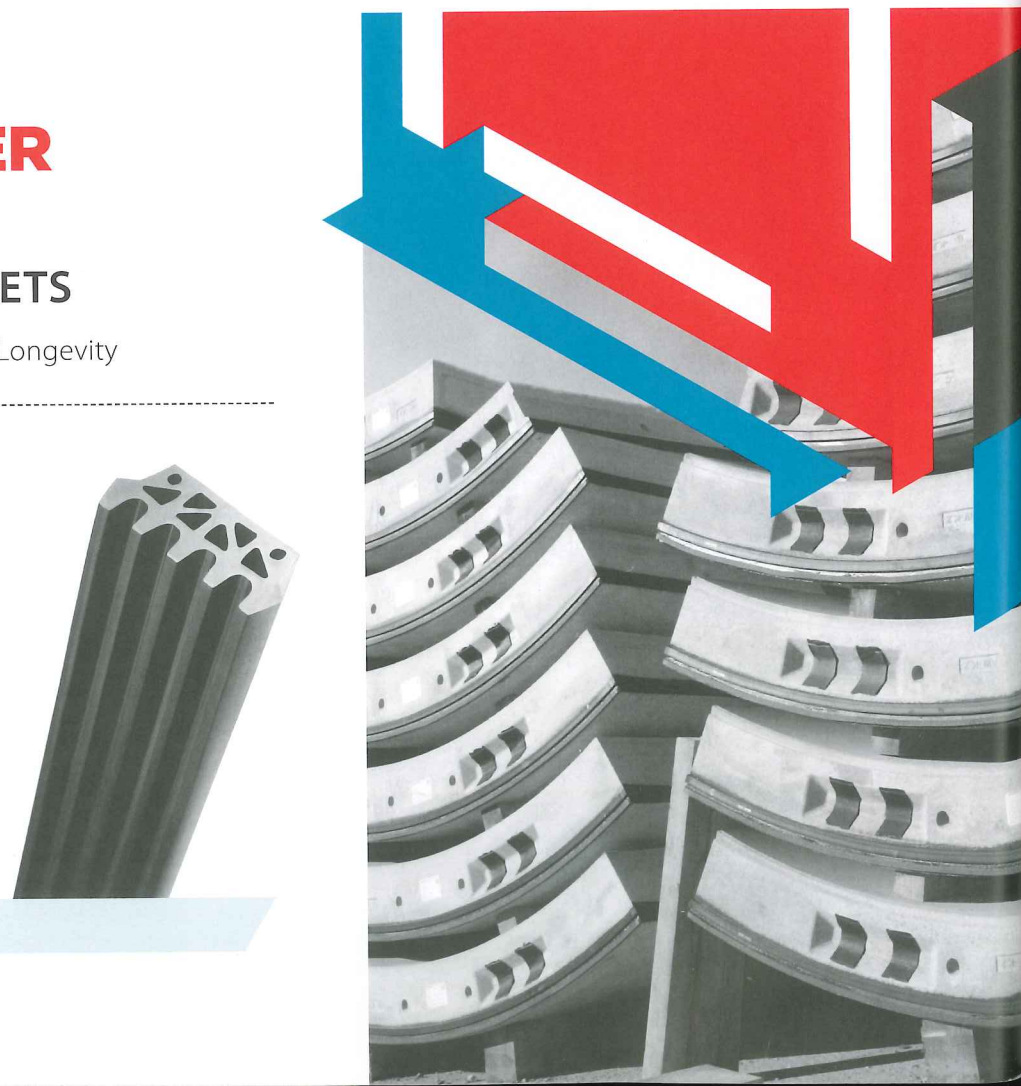
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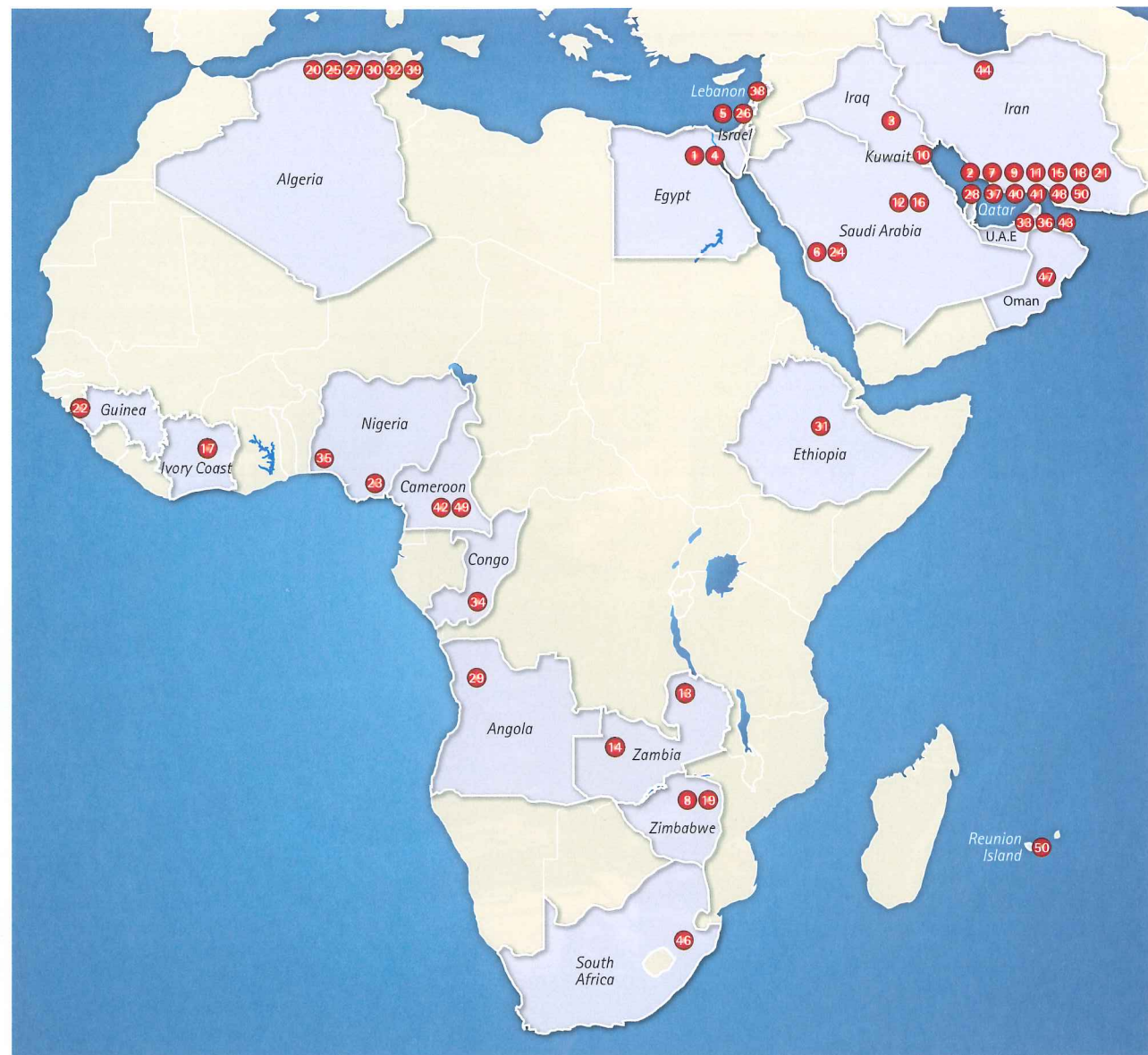


DOHA

DOMINATES

The Qatari capital has seized a great deal of tunnel work in preparation for the 2022 Fifa World Cup, the first to be hosted by a country in the Middle East. Aided by a cash rich economy built on oil, and the strong political will of the Emir, a mammoth rail development will see a record 26 TBMs working simultaneously

www.tunnelonline.info



Key

- | | | |
|---|---|---|
| 1. Cairo Metro Expansion phase three | 16. King Fahad Medical City carpark | 35. Lagos MRT system |
| 2. Al Shamal Sewage Treatment Plant | 17. Soubre hydropower plant | 36. Etihad high speed rail network |
| 3. Middle Euphrates International Airport utility tunnels | 18. Qatar Integrated Rail Network | 37. Al Khor sewerage development |
| 4. Cairo Metro Expansion phase four | 19. Kunzvi Dam development | 38. Beirut Rafic Hariri International Airport expansion |
| 5. Tel Aviv Light Rail System | 20. Algeria East-West roadway | 39. Saida Tiaret high speed rail |
| 6. Makkah to Taif road tunnel | 21. Doha International Airport | 40. Lusail Infrastructure Development |
| 7. Ashgal-Doha Bay road crossing | 22. Kaleta hydropower plant | 41. Lusail Mixed Use Development |
| 8. Route du Littoral Coastal Driveway undersea tunnel | 23. Naira Express road development | 42. Mekin hydropower plant |
| 9. Doha Storm Water Drainage Tunnel | 24. Haramain high speed rail tunnel | 43. Abu Dhabi Deep Sewer Tunnel |
| 10. Kuwait International Airport expansion – passenger tunnel | 25. Tissemslit to Boughzoul line | 44. Tehran Metro Line Six |
| 11. Doha water treatment plant expansion | 26. Gilon Rail Tunnel | 45. Kariba North Bank hydropower |
| 12. Riyadh Metro | 27. Rilzane to Tiaret railway line | 46. Ingula Pumped Storage Project |
| 13. Kundabwika hydropower plant | 28. Al Khor to Al Ruwais road | 47. Hasik-Shuwaymiyah road development |
| 14. Kabompo Gorge hydropower plant | 29. Cambambe hydropower plant expansion | 48. Doha WB Sheraton Hotel car park |
| 15. Ashgal to Lusail Expressway | 30. Algiers metro expansion | 49. Lom Pangar hydropower plant |
| | 31. Genale Dawa III hydropower plant | 50. Doha South Sewage Treatment Plant phase two |
| | 32. Boumedfaa-Djelfa high speed rail | |
| | 33. Al Mafaq hospital tunnel | |
| | 34. Brazzaville hydropower plant | |



- Backfilling (one or two components)
- Pre-excavation grouting
- Post/consolidation grouting



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for tunnel concrete segments

The RST Profile Monitoring System for Tunnel Concrete Segments is a series of tilt meters, fixed to the tunnel wall on each of the precast concrete segments erected in place as tunnel lining by a Tunnel Boring Machine (TBM). Its main advantage is that it can be deployed in the tight space available around the TBM to monitor deformation. A data logging system and RST's Geoviewer software are available to provide near real time displacement and generate a graphical representation of the tunnel convergence.

Typical installation of the RST Profile Monitoring System for Tunnel Concrete Segments with an RST flexDAQ Datalogger System.

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QATARI COUP

Qatar is preparing to set new records in tunnelling with 26 TBMs simultaneously boring 59km of twin bore tunnels creating the first phase of the vital Doha Metro. Technical journalist **Bernadette Ballantyne** reports

FOR A small country the Middle Eastern emirate of Qatar has huge ambition. It is currently preparing to embark upon the world's biggest tunnelling project as it seeks to deliver 59km of twin bored tunnel for a new city wide metro project. At peak this will see 26 TBMs simultaneously boring through conditions which are expected to include dolomitic limestone, chalky limestone and mudstone, to deliver four new lines of light rail.

The metro project is a key element of the Qatar Rail Development Programme which also includes a 400km heavy rail link that will connect the country with the wider GCC railway, and a 38km light rail network around Lusail City to the north of Doha. When complete in 2026 the metro will consist of 236km of line and 96 stations but to achieve this it must successfully delivering the first and most challenging phase of works – the underground lines.

TICKING CLOCK

To make things even more challenging Doha is in a race against the clock. In 2022 the country will be the first ever Middle Eastern state to host the FIFA World Cup. Newly constructed football stadia will be connected with the first phase of the new public transport system, which will consist of a red line running from the airport in the south through to Lusail to the north of Doha, the Green Line that runs west out to Education City, and the Gold Line that runs south west out to Al Rayyan.

This means that the project must be completed by 2019 to ensure that it is



fully operational by 2022 and so far the scheme is progressing well. After a huge international procurement program that saw Qatar Railways present its scheme all over the world, the first major design and build tunnelling contracts were awarded in late May 2013. Qatari companies are included in all of the consortia, which was a requirement from early bidding stages.

The first contract is the northern section of the red line which involves 13km of 6.17m i.d. twin bore tunnels. It was

Typical borehole section

The geological formations throughout the Doha Metro project are part of the Arabian Gulf basin, which has accumulated sediments with little interruption and has been influenced in only a minor way by tectonic activity, since the Palaeozoic Period. The thickness of sediment, overlying the basement rocks in Qatar is estimated to be over 10km. Fill and marine deposits overlay gravelly limestone, mudstone, shale and finally limestone and chalky limestone.

awarded to a consortium led by Italy's Impregilo, with Korea's S.K. Engineering & Construction Co, and Qatar's Galfar Al Misnad Engineering & Contracting. The scope of work includes design and construction of seven underground stations between the proposed Msheireb Underground Station and Doha Golf Course via Doha West Bay. For this, four TBMs are proposed to bore the required rail tunnels. The tunnels will be built at an average depth of 20m below ground.

The second contract is for the southern section of the red line running from Doha south to the Sheikh Hamad International Airport. It is slightly longer than the northern section with 13.8km of twin bore, and also includes a 1.2km single operational link. This was awarded to a consortium led by Qatari Diar Vinci Construction (QVDC) and includes Korea's GS Engineering and Construction Corp, and Qatar's Al-Darwish Engineering. The package includes construction of six underground stations and is expected to use five TBMs boring at up to 50m below ground level.

At 16.6km the longest twin bore to be awarded so far is the

Above: Artist's concept of a future station

green line which was won by Austria's Porr in joint venture with Saudi Bin Ladin Group (SBG) of Saudi Arabia and Qatar's Hamad Bin Khalid Contracting Company. The package also includes eight underground stations and will run at approximately 20m below ground.

A final tunnelling contract for the 15.2km Gold Line is still to be awarded. Meanwhile Korea's Samsung C&T with Brazil's OBRASCON Huarte Lain and Qatar Buildings Company will build two major stations at Msheireb and Education City.

Given the size of the scheme it is not surprising that 20 consultants are engaged in various roles on the project including US firm Jacobs as project manager for the Red Line, US consultant Hill International as project manager for

Table 1. Contracts awarded to date

Contract	Award Date	Contractors
Major Stations – Musheireb and Education City Stations	23/05/2013	Samsung C&T Corporation, Obrascón Huarte Lain S.A (OHL) & Qatar Building Company
Design and Build Package 1 – Red Line North Underground	16/05/2013	Impregilo SpA – SK Engineering & Construction Co. Ltd. – Galfar Al Misnad Engineering & Contracting W.L.L. JV
Design and Build Package 2 – Red Line South Underground	16/05/2013	QDVC – GS Engineering & Construction Corp. – Al-Darwish Engineering W.L.L. JV
Design and Build Package 4 – Green Line Underground	16/05/2013	PORR Bau GmbH – Saudi Binladin Group Company Ltd – Hamad Bin Khalid Contracting Co. W.L.L. JV
Provision of Internal Audit Services	06/01/2013	KPMG
Integrated Risk Management System (IRMS)	04/12/2012	Active Risk
Real Estate Consultancy Services	30/09/2012	Barwa Real Estate Company
Project Management Consultancy Services for Metro – Phase 1 [Red Line North and South]	16/07/2012	Jacobs International Holdings Inc.
Advanced Enabling Works	28/06/2012	PORR – SBG – HBK JV
Concept Design for Architectural Branding	28/06/2012	Aedas Architects LLC
Independent Safety Assessor (ISA)	28/06/2012	Lloyds Register Qatar LLC
Concept Design for Architectural Branding	28/06/2012	Atelier4D Architects Partnership
Concept Design for Architectural Branding	28/06/2012	Van Berkel En Bos U.N. Studio B.V
Project Management Consultancy Services for Metro – Phase 1 [Gold Line and Msheireb/Education City Stations]	21/06/2012	Louis Berger – Egis Rail JV
Project Management Consultancy Services for Metro – Phase 1 [Green Line]	18/06/2012	Hill International
West Bay Transit System Project Feasibility Concept Et Preliminary Engineering Request for Proposal (at Grade Option)	16/05/2012	Jacobs International Holding Inc.
Geotechnical Investigation II - Geotechnical Investigations for Underground / Elevated and at Grade Sections	01/04/2012	Schlumberger Overseas S.A
Ground Water Aggressiveness Study	26/03/2012	Schiessl Gehlen Sodeikat GmbH
Tunnel Ventilation Study	26/03/2012	HBI Harters Ingenieurs Conseils
Consultancy Services for Environmental Impact Assessment	21/03/2012	Energoprojekt-Entel Ltd
Consultancy Services for Tender Design MEP & HVAC	15/01/2012	Dar Al Handasah (Shair and Partners)
Consultancy Services for in Relation to an Independent Review (Additional Services) for DWBPMS	01/08/2011	W.S. Atkins and Partners Overseas
Consultancy Services for Geotechnical Investigation-Underground Line Sections	04/06/2011	Schlumberger Overseas S.A
Consultancy Services for in Relation to an Independent Review for DWBPMS	01/06/2011	W.S. Atkins and Partners Overseas

Source: Qatar Rail

the Green Line, and a joint venture of US firm Louis Berger with France's Egis Rail is project manager for the Gold Line.

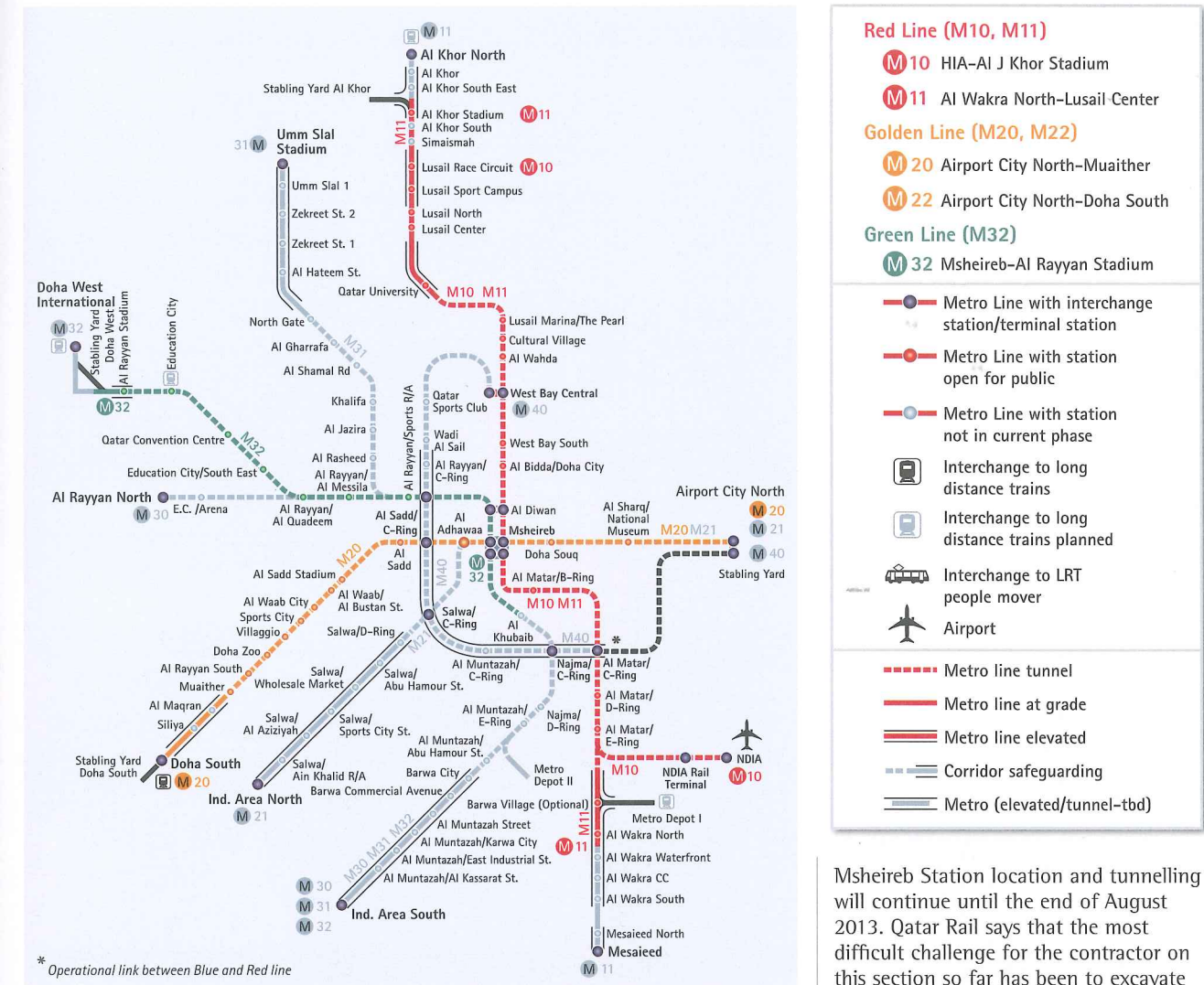
As is usual for major tunnelling projects the underground works have been tendered as design and build contracts leaving the ground condition risk with the contractors. This is in direct contrast to neighbouring Abu Dhabi where the Abu Dhabi Sewerage Services Company chose to retain this risk on its 40km deep sewer tunnel to make the project more attractive to international firms, and reduce bid costs. Qatar Railways Company (Qatar Rail) told *Tunnels*: "Successful contractors are required to undertake further investigations on award of contract to

26
The number of TBMs expected to bore the project simultaneously. Considered to be a new world record

verify the information and assumptions prior to design and tunnelling arrangements finalisation. Tenderers have been positively encouraged to identify risk and price accordingly. All ground risks therefore ultimately sit with the contractor consistent with the ethos of a lump-sum, fixed-price design and build contract intended to provide QRC with certainty from the outset," it said in a statement, however the organisation says that contractors who can outperform the contract will reap the benefits. "Conversely, and consistent with the certainty requirement, QRC will not seek to limit benefit derived from better than anticipated conditions."

NEW GROUND

Qatar does not have a history of underground tunnelling of this scale which makes the ground investigation all important for contractors. "Tunnelling in Doha is going to be difficult, there is no doubt about it," says a senior tunnelling consultant close to the scheme. "The ground is not well known and some



of it is karstic limestone, which has voids in it as a result of water passing through and wearing it away." This phenomenon can create large voids in the ground and can also lead to what the consultant describes as "strange steep rock cliffs below ground". The city also has a high water table.

"There are numerous design and construction challenges for the Doha Metro, related to the expected ground and groundwater conditions," it says. "These are the spatial variability of key geotechnical properties, such as the degree of weathering and fracturisation of the encountered geomaterials; the possible existence of medium karstic features, such as karstic depressions and in some cases voids; and the presence of numerous perched aquifers, which during excavation of the cut and cover pits will call for detailed dewatering."

Qatar Rail says that all of these factors will be further investigated by the contractors in order for them to better understand the geo-mechanical behaviour of the encountered 'ground' types; evaluate the expected tunnelling conditions through the project network; and apply the most appropriate techniques to ensure the highest safety and quality standards.

Although the tunnelling contracts have only just been awarded, enabling work had already begun onsite. The Porr/SBG/HBK group has been undertaking the enabling works contract which was awarded in mid 2012 involving the utility diversions and site hoarding to prepare packets of land allocated to the project. From a tunnelling perspective, there are currently 2 micro-tunnelling machines working at the

Above: Figure 1, The envisaged Qatar Metro map

Below left: Qatar Metro rolling stock concept

Red Line (M10, M11)

- M10 HIA-AI J Khor Stadium
- M11 Al Wakra North-Lusail Center

Golden Line (M20, M22)

- M20 Airport City North-Muaither
- M22 Airport City North-Doha South

Green Line (M32)

- M32 Msheireb-AI Rayyan Stadium

Metro Line with interchange station/terminal station
 Metro Line with station open for public
 Metro Line with station not in current phase
 Interchange to long distance trains
 Interchange to long distance trains planned
 Interchange to LRT people mover
 Airport
 Metro line tunnel
 Metro line at grade
 Metro line elevated
 Corridor safeguarding
 Metro (elevated/tunnel-tbd)

Msheireb Station location and tunnelling will continue until the end of August 2013. Qatar Rail says that the most difficult challenge for the contractor on this section so far has been to excavate in a very congested area with numerous existing underground utilities, including pressurised potable water pipes and live electrical and communication cables. One of the tougher challenges is to stabilise the side walls of the excavated shaft having to support unstable soil layers. Beyond the challenges of ground conditions and logistics a more immediate requirement is for the contractors to source the multitude of tunnel boring machines. With average order times being around 12 months and projects being undertaken simultaneously the industry could be in for a TBM boom. Experts expect to see slurry or EPBM machines used in Qatar. Despite the challenges however the prospects for Qatar are good.

Thanks to recent mechanised tunnelling in neighbouring Abu Dhabi and Dubai and Saudi Arabia the region has begun to build up its expertise in underground construction, ably assisted by the world's leading firms.

However for Doha the clock is ticking and the race to complete the world's largest simultaneous bore is now on



CUTTING THE SILK ROAD

Lawrence Williams visits the Salmankas tunnel site with tunnel supervisor Ersin Yilmaz

THE ANCIENT 'Silk Road' is perhaps the most famous trading route of all time running from China, through India, Pakistan and Iran into Europe. Over time this route grew to cover a broad range of trading paths, particularly at the European end, but one of the oldest, and most significant, sections ended at the Black Sea port of Trabzon in Turkey, with the final 130km or so being from Bayburt, over the Salmankas Pass at an elevation of 2,280m, following a fast flowing stream and river to Arakli and then along the coast to Trabzon itself.

Now the Turkish Road Directorate has awarded a contract for a new road tunnel on this, the shortest road route between Trabzon and Bayburt, below the highest elevations to Turkish contractor Asyol Yapi. Project designer is TTS Uluslar Arasi Muhendislik ve Mimarlik.

The Salmankas tunnel is thus the most critical construction project on the new road section joining Bayburt and Trabzon which will shorten this historical Silk Road route and, most importantly, will make it accessible to modern day traffic year round. Currently the section of this existing road over the Salmankas Pass is unmetalled, in a poor state and can be completely closed off to traffic for up to six months of the year due to excessive snowfall and plunging temperatures which can drop to as low as minus 30°C. The road is tarmaced up to the point the tunnel commences at an elevation of around 1,940m above sea level.

The 4.03km long tunnel will, on its own, cut some 16km off the existing route traversing one of the most difficult sections of the old road. The full road enhancement project will also include the construction of three viaducts between the new tunnel and Bayburt.

The initial Asyol Yapi tunnel project only involves driving a single tube although a second is planned and the south portal for this has already been developed as part of the current contract, but the contract for the parallel tunnel itself has not been let yet and may be in the 2013 or 2014 Roads Administration budget timed to commence when the current tunnel is complete.

The current Salmankas tunnel project was awarded in mid-2011, with test drilling then undertaken by the contractor from surface along the tunnel length to check the rock types and competence of the ground to be worked. Principal rock types that will



360

The amount of explosives used, in kilograms, per blasting round



be encountered are basalt and andesite. Actual tunnelling work commenced in October 2011 and is due for completion in January 2014.

EQUIPMENT

The drilling units actually driving the tunnel are two Sandvik DD320-40 twin boom drill rigs mounting HLX5 drifters. One drills from the south end of the tunnel and the other from the north. These drive the 10m high by 12.3m wide tunnel by first drilling and blasting a top heading, leaving a 3.5m bench which is then mined out after the top heading is mucked out. For the single tube tunnel safety refuges are being blasted out of the sidewall at 900m intervals. If and when the second tube is built the plan is to drive pedestrian accesses between the two tubes at 350m intervals as emergency exits.

The Sandvik DD320-40 is a compact

Above, top: The temperature in the first 100m of tunnel has hit -15°C

Above, bottom: The TRY 100M (USD 51.6M) project should be completed in 2015

two-boom electro hydraulic jumbo for drilling in drifting and tunnelling of 8 to 49m² cross sections.

The TB 40 universal booms have a large optimum shaped coverage and full automatic parallelism. The booms can also be used for crosscutting and bolthole drilling.

The powerful four-wheel-drive centre articulated carrier ensures rapid and safe tramping with good balance.

The Asyol Yapi drillers are satisfied with the performance rate, with the rigs currently drilling through the extremely hard basalt and achieving a 120 hole round using 4.3m drill steels and 45mm RT300 button drill bits (used because of the very hard ground) inside two hours. Some 360kg of explosive are used with the 120 hole, v-cut excavation round.

A design advance rate of 4m per round was given, though realised rate has been 3.75m on average. Mucking out is with a Cat 966 wheel loader tipping into contractor-owned 30t on highway trucks. The muck is delivered to stockpiles near the site which may be used for roadstone by the Turkish Roads Authority. The tunnel is being driven from both ends with the south end of the tunnel at 1,200m in at the time of the site visit, much further advanced than the north end (only 150m advanced) – in part because the north portal was in much more difficult ground requiring jet grouting which

slowed down the start-up – and also because the severe winter weather conditions, which last for the best part of six months, make access to this end of the tunnel by the contractor's workforce, which is being accommodated close to the south portal, virtually impossible during periods of such extreme winter conditions. The current schedule calls for one 4m round to be drilled, blasted and mucked out per shift, with two working shifts per day.

SUPPORT

At the southern portal ground conditions were better, but still required a 50m long pipe umbrella put in – at 55m width, sufficient to consolidate the ground above the portal for the second tunnel as well so it will be ready for construction start as soon as a contract is let for it. Some 9m long umbrella holes were drilled using a Sandvik DX700 rig drilling 115mm holes to accommodate 114mm diameter pipe to provide cover over the first 55m of the tunnel. Additional support in the portal section included steel arches, 6m long, 32mm diameter self drilling rock bolts, wire mesh and a 300mm thickness of shotcrete.

In the main tunnel section, primary support is with 4m long 28mm diameter grouted rebar rock bolts, placed by the Sandvik drill rigs, with 5 to 15 bolts per metre depending on rock

Above: Geology encountered has been slope rubble clay, decomposed volcanic rocks, Basalt and Andesite

conditions, supporting wire mesh and followed by 150–250mm of shotcrete.

The final tunnel lining of a concrete skin 500 to 600mm thick including PVC waterproofing, is being placed using locally manufactured formwork behind the advancing face. Finished tunnel size is 10.6m wide by 6.85m high from inside of concrete lining to roadway.

The concrete batching plant on site is from Turkish specialist supplier Meka. Formwork is provided by Ceka Beton Kalibi Imalat Insaat Sanayi ve Ticaret, and the shotcrete manufacturer is Titan.

Interestingly, because of the extreme weather conditions which can be experienced the plant is fitted with diesel-powered heater systems to prevent the concrete slurry freezing when the temperature drops significantly (-15°C).

As *Tunnels* goes to press, some 64 per cent of the tunnel is excavated, and one quarter of the lining



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BREATHING TUNNELS

Roger Gale of KGD Developments discusses making road tunnel environments safe through effective filtration

THE FIRST tunnels were constructed some 4,000 years ago to allow pedestrians and chariots to pass under the Euphrates River in what is now Iraq. 2,000 years ago the Romans became very successful as tunnel builders and built a tunnel around 5.6km long. When the Roman Empire died the tunnelling industry died for another 1,000 years. It was revived in Moscow around 1,500 AD. The construction of these tunnels was very labour intensive. Then the industrial revolution in England needed a good transport system and so tunnels were made through hills and mountains by labourers using machines. While not the first tunnel built under a river, the Thames Tunnel in London was the first such tunnel in England. The tunnel was built by Sir Isambard Brunel and his perhaps more famous son, Isambard Kingdom Brunel. The Thames Tunnel was being built through soft clay and thus resulted in many accidents and deaths. Marc Isambard Brunel invented the tunnelling shield to construct the tunnel; the principle is still used

today. It was not until the advent of the motor car and the lorry that the number of tunnels increased even more dramatically. With the increase came the use of explosives and TBMs to make tunnels through mountains. There are now two more types of tunnel, the floating tunnel and the immersed tunnel. The original tunnels built were done so for the task of overcoming geological problems namely rivers and mountains. Now they are also used to overcome manmade obstacles, cities. The vehicular traffic has increased to such a degree that to travel through a city by car takes as long in the 21st century as it did in the 19th century. Using London as a Western example of vehicle speed. In the 19th century a horse and carriage would travel at 13.6km per hour. This was the same speed of travel until the congestion charge was introduced in 2003 (which charges certain types of vehicle to use the road in central London) the speed then went to 16km per hour. In Jakarta the speed is 12km per hour. When we drive into road tunnels we can see and smell the pollution. We

know it is dangerous. We know that to live close to a tunnel portal is not good but we must do it. It is possible to forecast the volume of traffic in a tunnel but many times that estimate is too low. We now have the ability to filter the air in tunnels so as to make driving in those tunnels safer and also the city itself healthier.

BASICS

There are three basic types of installations used in the filtration of air in a road tunnel. These are 'bypass' (built into a side tunnel), 'stack system' (chimney) and 'ceiling mounted' (built on to a platform in the roof). The first tunnel filter systems were installed in Japan and were mechanical filters normally 'bag filters'. With all mechanical filtration systems (a household vacuum cleaner is one such) as the bag collects more and more dust, the fan pulling the air through the system must do more work. The energy requirement increases so when the fan is sized for the system the fan must be able to still collect dust when the bag is full and requires changing. The day-to-

The dangers of inadequate filtration

- Vehicle exhaust raises the risk of heart attacks
- Vehicle exhaust causes hardening of the arteries and strokes
- Unborn baby receives vehicle pollution through the mother
- Vehicle emissions from a Los Angeles freeway directly linked to brain damage
- Canadian study links vehicle exhaust PM 2.5 to increase in asthma

day running cost therefore of this system is very high and due to inflation would only get higher.

A system that had been growing in popularity since the 1940s is the electrostatic precipitator (EP).

The EP is a filtration system which uses a high electrical direct current to give an electrical charge to particles that are then collected on oppositely charged flat plates.

This EP system was designed and installed to overcome the problems with the mechanical filter and be as, or more efficient. Among the advantages of the EP was that as it collected the particles the pressure drop, which was low at the start of a collecting cycle, did not get significantly higher throughout that collecting cycle.

This meant that the fan could be smaller than the one specified for a bag filter and could be size for a low pressure drop. The cost advantage of an EP system is very significant.

The Japanese system still had one major flaw, which was that it had wires for the ionizer (the section giving the high electrical charge to the particles). These wires would break due to the vibration caused by the high voltage and to electro-discharge machining. The problem is that it is impossible to calculate when a wire would break. Any wire that broke then required replacing, which therefore entailed a high maintenance cost.

The first tunnel filter designed by the author used what is now called a 'Saw Tooth Ionizer' and had negative ionization (both were later installed in Japanese tunnel systems). This saw an increase in the life expectancy of the ionizer and, due to the negative ionization a much higher efficiency when compared to the positive charging system. It was generally accepted that there were still some disadvantages to what has been called the European system' so it was decided to investigate the disadvantages and design a filter system which would overcome the disadvantages.

With the standard system the filter

16

Kilometers per hour is the speed at which one can cross modern day London by car

could crash meaning that no particulate would be collected. Also if one filter crashed then many others would also crash. As tunnels get longer there is a requirement for removing the exhaust gases by using activated carbon. Activated carbon has minute holes that increase the surface area used in collecting the gas. As an example a 10mm cube can have a surface area of circa 1500m². These minute holes get blocked with the particulate. If an EP crashes then the holes get blocked and the carbon would need to be changed prematurely.

OBJECTIVE

The object of the study was to develop an electrostatic precipitator filter system that has a higher efficiency against velocity, is electrically more stable than any other systems and would not collapse if the collector section of the filter cell was short circuited. All the filter systems presently available were susceptible to the latter. It was determined that the method of testing to be used should be Eurovent 4/9. The method should determine the weight efficiency for a single electrostatic precipitator cell. The method should also be able give a particle count to determine the efficiency for varying particle sizes.

METHOD

Electrostatic precipitators have changed over the years. The original precipitators had wires in the ionising section to generate the corona discharge which is necessary for the precipitator to work. The problem with using wires was that they could break due to the high voltage vibrating the wires and electro-discharge machining. Other disadvantages are that if the collector cell is short circuited, for whatever reason, then that cell and any other connected to it also fails. We wanted to address all these problems and design a filter which could be adjusted for efficiency without the need to increase the cell dimensions.

To do this we had to analyse the way that electrostatic precipitators worked and how to improve them. A system was devised to test the filter system and to determine the disadvantages of the present filters. The test system comprised of outdoor air mixed with particles from a particle generator (diesel generator), a duct system, a filter housing which could take different sizes of filter and a fan with adjustable air flow. The duct was equipped with sensors before and after the filter to measure the airflow and particle weight and particle counting instruments (Figure 1).

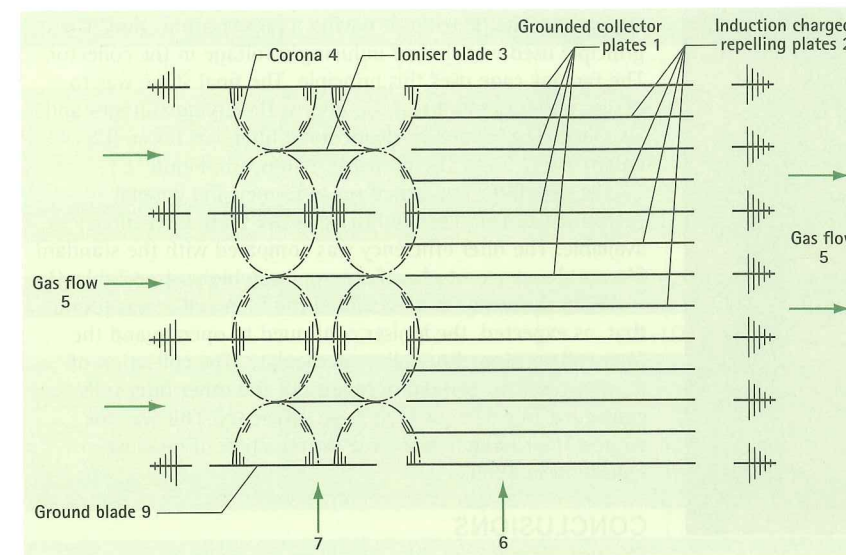
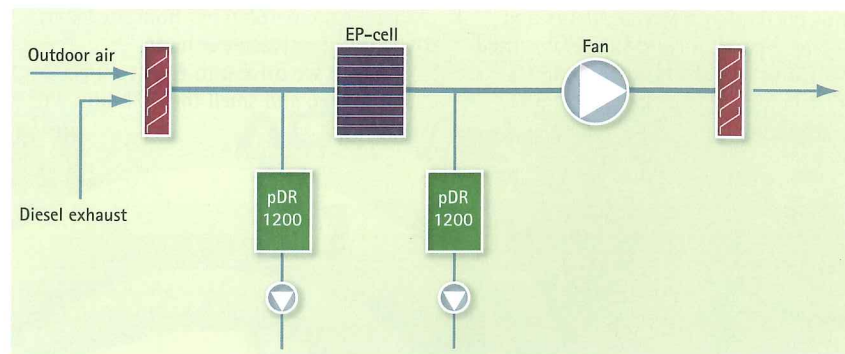
Filter arresstance (A) is calculated by the following equation:

$$W_d - \text{weight of dust downstream of the filter } [\mu\text{g}/\text{m}^3]$$

$$W_u - \text{weight of dust upstream of the filter } [\mu\text{g}/\text{m}^3]$$

A fluke particle counter was used in conjunction with the pDR 1200 to ascertain the particle size and the efficiency

Below: Figure 1, the test system



against particle size.

The Eurovent 4/9 fractional efficiency method uses a laser particle counter to count particles within specified ranges upstream and downstream the test device.

A given particle size range means all particles between two specified diameter values. The number of ranges is equipment specific, for instance, the Fluke counters have six ranges, (0.3µm–0.5µm, 0.5µm–1.0µm, 1.0µm–2.0µm, 2.0µm–5.0µm, 5.0µm–10µm and >10µm).

The basic expression of the fractional efficiency for a given

Above: Figure 2, the induction electrostatic filter

Below: An electrostatic precipitator in Gyeongju, South Korea

particle size range, is the ratio of the number of particles retained by the filter to the number of particles fed upstream of the filter. The efficiency measurement is done by a series of 12 counts of one minute, conducted successively upstream and downstream of the test device. Between each count transfer lines are purged for one minute.

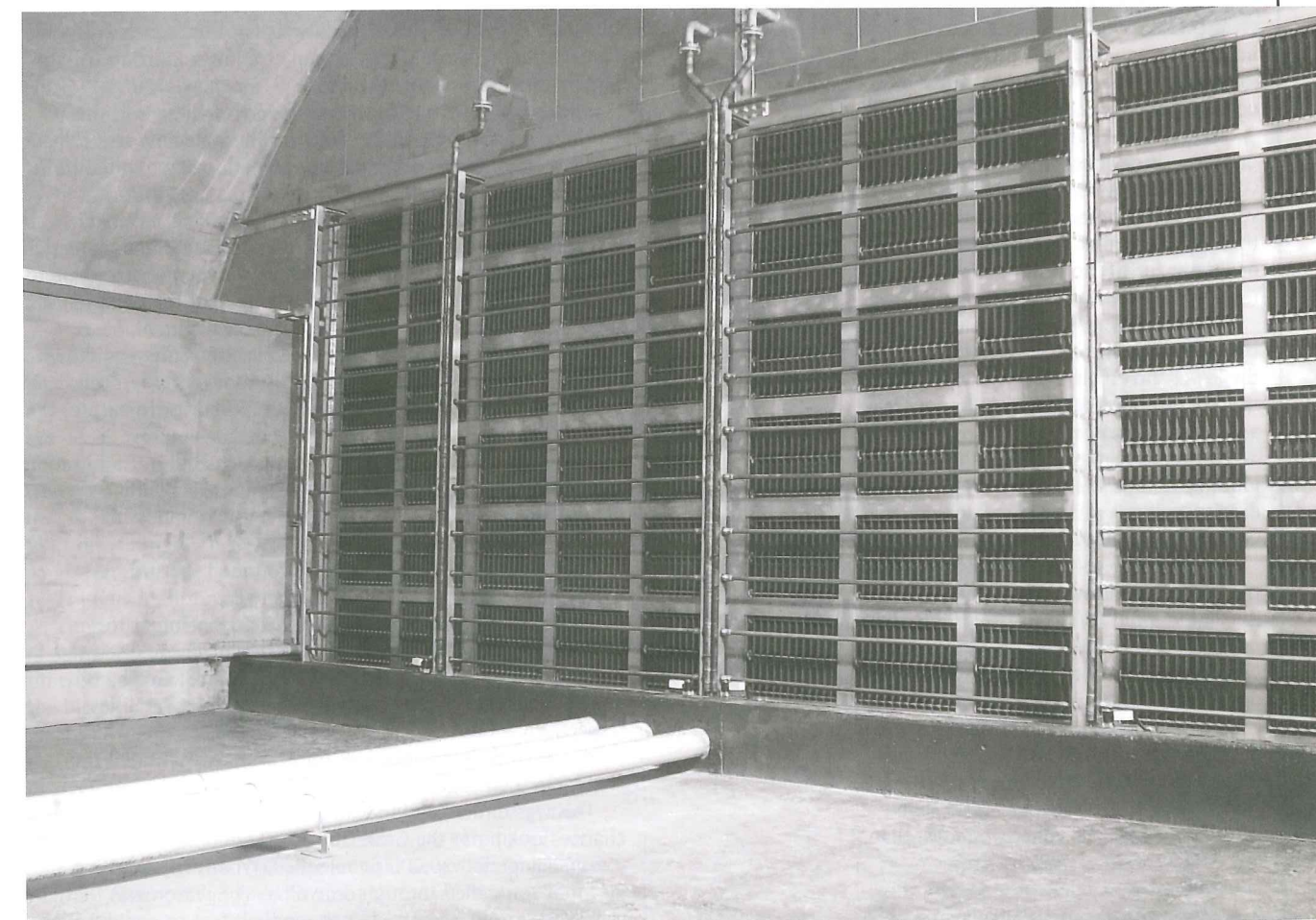
The fractional efficiency (E1) for one repetition is calculated with the following equation:

$$N_1 - \text{downstream count at time 1,}$$

$$N_2 - \text{upstream count at time 2,}$$

$$N_3 - \text{downstream count at time 3.}$$

Results showed that for a standard filter which is charged on the ioniser and collector the efficiency varies with the air velocity this is known and used to determine the efficiency of a system. A filter system is designed so that it is very close to arcing. This gives the highest efficiency. The problem with this is that with a system where more than one cell is powered with the same power supply when a cell discharges the power is lost in all interconnected cells for a fraction of a second. There is a time lag between the discharge and the cell/s regaining





Above: The health risks from poor understanding, and poor implementation of ventilation are clear

the previous charge. During this time there is a lowering of the efficiency in the system. This is a big disadvantage especially if one cell has a short circuit. If a short circuit happens, the total system shuts down. This is perhaps the one main area where the efficiency and filter cost could be improved.

As the collector is a big capacitor and that the EP was a capacitor which had a controlled discharge charging the capacitor was considered. The ioniser charges the particle, however it was the intention to quantify the effect of the ionizer with a varying velocity and a constant collector voltage.

Normally due to the way the power generator is designed as the ioniser voltage is increased so the collector voltage also increases. A generator was used for the ioniser and a separate generator for the collector and the results are shown in Table 1.

As can be seen the velocity affects the efficiency. The higher the velocity the lower the efficiency.

The ionising voltage was varied with a constant airflow in Table 2.

As can be seen to increase the ionising voltage we increase the efficiency and we can have a higher velocity with a high efficiency.

The collector voltage was varied with the ionising and the air flow constant (see Table 3).

As can be seen with at lower collector voltage the efficiency was lower but due to the high ionising voltage the collection efficiency was not dramatically decreased. Below 3kV however the efficiency dropped dramatically.

The results showed that with a high collector voltage the collector could arc, which caused a drop in efficiency. Looking at the design of the ioniser it was possible to cause the collector

to accept a charge without having a power connection. The principle used was that of inducing a voltage in the collector. The faraday cage uses this principle. The final stage was to design an ioniser and test the filter with varying voltages and air speed. The induction electrostatic filter was borne (US Patent 7,942,952). The principle is shown in Figure 2.

The new filter was tested for efficiency and general performance. The filter had to be better than other filters available. The filter efficiency was compared with the standard filter and was seen to be of a magnitude higher (see Table 4).

When the study short-circuited the filter cell it was found that, as expected, the ioniser continued to operate and the filter cell continued to collect particulate. The collection of the shorted filter cell did decrease but the other filter cells continued to collect at their rated efficiency. This was the biggest improvement since the introduction of negative ionisation in 1989.

CONCLUSIONS

The tests highlighted that the efficiency of the system was much higher than the existing filters and used less energy to attain the same efficiency thus offering a saving in running costs. The installation of the IEP system showed other cost savings due to only requiring one power generator.

Operational Advantages

In the old system if one cell was shorted then all the cells connected to that filter will shut down. With the IEP should one cell short circuit, only that filter cell will be affected.

The IEP system allows the shorted filter cell to collect particulate but at a lower efficiency, when the cause of the short is removed the cell immediately attains full efficiency. The IEP system was less prone to arcing even when operating at a higher voltage. It could also be run at a lower ionizing voltage and maintain the same efficiency.

This is the problem. The vast majority of tunnels in the World were built before either the health problems were fully understood or built with an underestimation of potential traffic flow through the tunnel.

The Lane Cove Tunnel in Sydney, Australia, is a classic example of this. The tunnel was finished in 2007 and almost immediately started to have problems with the pollution due to the quantity of traffic. The stated requirement for a single pass filter was 80 per cent.

This is easily achievable with the IEP filter system as shown earlier. After every installation of a filtration system, the system is tested by at least one accredited test authority. In each case the required efficiency has been exceeded.

There is however a major problem which is that if a filtration system is required to be installed it is impossible without disruptive excavation to the tunnel. So it was impossible to install a filtration system.

The author and his colleagues recognised that this is a problem with many roads that didn't seem to be being addressed by the filtration industry. While looking at the problem two disastrous European tunnel fires were discussed These being the Mont Blanc Tunnel, and the St Gotthard Tunnel fires. In these fires there were 38 and 11 fatalities respectively all due to smoke inhalation.

It is known that smoke kills but it also disorientated the victims in the tunnels.

This was understood but in was not that evident until, by chance, looking at the Great Smog of London in 1952. During a four-day period 20,000 people died. What was surprising was that some died through drowning. The reason was that visibility was 1m. they could not see their feet so could not see

Table 1. Separate generators

Air Flow	0.3-0.5µm	0.5-1.0µm	1.0-2.0µm	2.0-5.0µm
4m/s	93.39%	96.03%	97.70%	96.91%
6m/s	88.80%	93.73%	96.38%	95.86%
8m/s	84.20%	93.13%	96.77%	95.75%

Source: KGD Developments

Table 2. Varied airflow

Voltage	0.3-0.5µm	0.5-1.0µm	1.0-2.0µm	2.0-5.0µm
15kV	90.01%	94.94%	98.56%	98.12%
14kV	86.1%	92.1%	97.5%	98.4%
12kV	83.6%	88.9%	96.4%	97.8%

Source: KGD Developments

Table 3. Constant airflow

Voltage	0.3-0.5µm	0.5-1.0µm	1.0-2.0µm	2.0-5.0µm
6.5kV	90.4%	95.6%	98.0%	98.3%
4.6kV	84.1%	90.9%	97.4%	98.5%

Source: KGD Developments

Table 4. Filter efficiency

Particle size	0.3-0.5µm	0.5-1.0µm	1.0-2.0µm	2.0-5.0µm
Efficiency	93.6%	95.9%	97.2%	98.3%

Source: KGD Developments

where they were walking.

In the Mont Blanc Tunnel this was 0.5m. So it was thought that there are two objectives. Firstly to remove exhaust pollution on a daily basis, and secondly to remove smoke in the event of a tunnel fire.

Having specified the problem, to devise a system to remove exhaust pollution and smoke from a tunnel fire. It was decided to investigate the problem of fitting an EP into an existing road tunnel.

The requirements were to have a filter to clean particulate and a fan to move the air through the filter. It was realised that there were two basic problems with the filter system, the maximum economical speed was circa 10m/sec and that of the fan which required space.

It was soon understood that there was a fan available, which was the jet fan. The problem was that the jet fan moves the air at up to 35m/sec. To use the jet fan it would require a filter measuring in at least three times the size of the face area of the Jet Fan.

This is without taking into consideration the pressure drop. The concept of spinning the air was discussed. The thought of spinning the air and ionising the particulate at the same time was addressed. In theory it meant that the faster the air, the bigger the force to throw the particulate to the side of what had to be a tube.

A 'Saw Tooth Ioniser' was made and twisted through 360 degrees and fitted into a 100mm tube. This one tube prototype was tested in an existing tunnel and it was shown that the concept was viable. A number of tubes were fitted together and it was shown that the system could be scaled. This meant that the filter system could be sized to the jet fan.

The principle was therefore that the filter system would be

10

Metres per second is roughly the maximum economical speed

100

Per cent reversible filters do not require any modification

attached to the jet fans in the tunnel, using the same installation method, and the cleaning of the air would be progressive. This meant that the air cleaned by one system would entrain the pollution in the tunnel and this would be drawn into the next filter which cleaned the air and then the cycle would be repeated. Therefore for the majority of the time the filter system would be used to clean the air of vehicle exhaust. The filtration system can be fitted to all existing road tunnels as well as submersed and floating road tunnels. There is one occasion when the filter has an emergency response.

There have been many deaths due to the smoke generated by a tunnel fire. As has been seen the filter system is fitted to the Jet Fans. In the event of a fire, the filtration system and the jet fans would be activated and the smoke drawn through the filters.

The smoke would be removed and this would allow the vehicle occupants time to escape and the fire fighters to tackle the fire.

The filters are 100 per cent reversible without any modification to the filter. This means that the tunnel control centre can direct the air movement and clean the smoke at the same time

IN THE SMOKE

Petr Pospisil of consultancy Tunnelventilation.pro gives this reflection on the realities of a fire in a tunnel, and the disorientating effects that can still be in effect despite ventilation



Petr Pospisil

An associate of Tunnelventilation.pro, Petr has over 20 years in tunnel ventilation and safety

IN 2003, I participated in smoke tests in a long road tunnel in Slovakia. Ten years later I remembered my personal experience and asked myself: Where are we now with safety and ventilation of road tunnels. The conclusions are in some aspects disillusioning.

The Branisko tunnel is a 5km long road tunnel with bidirectional traffic in Eastern Slovakia, which was opened in 2003. An escape tunnel is situated parallel to the road tunnel. The tunnel is equipped with a semitransversal ventilation system with smoke extraction dampers, which was designed in the 1990s. Having to inherit a tunnel ventilation concept which was not really adequate, particularly in controlling the longitudinal airflow, I contributed on the final design, and was responsible for the operation and control algorithms, the commissioning and acceptance tests of the tunnel ventilation system. Beside that, I worked out the concept, design and realisation of the escape tunnel ventilation system.

SMOKE EVENT

At the final acceptance test, smoke tests were carried out to demonstrate the effectiveness of the fire ventilation system. It has to be pointed out that before that all safety systems should have been successfully proven. To simulate tunnel fires, we proposed military smoke generators that were designed originally for the screening of tanks, producing a large amount of artificial smoke, with a heat release sufficient to enable a stratification. However, health aspects were not addressed. In fact, the test smoke was quite irritating to the respiratory system.

The first test was a success. Although the smoke extraction capacity was not sufficient, due to high duct leakages, the fire ventilation system was able to limit the spread of smoke and finally to remove the fumes from the tunnel. During the second smoke test, a breakdown of the power supply led to the failure of one of two exhaust fans, and additionally of one supply fan in the

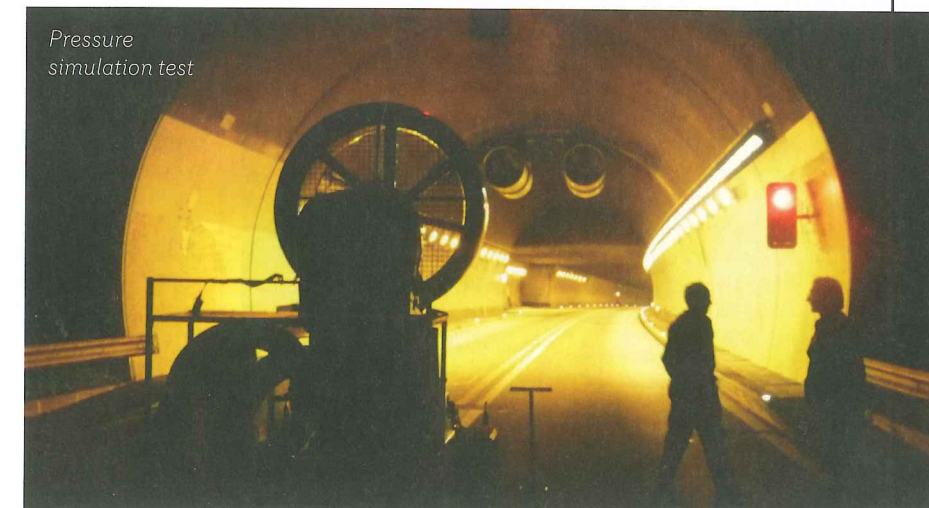
opposite tunnel section which was used to slow down the longitudinal airflow. As a consequence, the smoke spread over the whole length of the tunnel due to strong buoyancy forces. Later, the power supply could be fixed and the smoke finally removed from the tunnel.

I attended the smoke tests in the tunnel standing beside a cross passage to the escape tunnel, and left my car in a lay-by opposite to the cross passage. When the tunnel was filled with smoke due to the system failure, I decided to evacuate myself to the cross passage which was supplied with fresh air. The power supply of the escape tunnel ventilation was attached to the UPS according to my recommendation, enabling a high level of availability.

After a few minutes, I realised that my dog was trapped in the car, and that the smoke could affect his health. Therefore, I decided to save my dog and pick him up. The distance between the cross passage and the car was approximately 20 m. While walking in the tunnel, the visibility was nearly zero and I hold my breath to not respire the fumes. I found my car quickly, took out my panting dog, and tried to get

back to the cross passage. However, it took longer than expected to reach the opposite tunnel wall, which was only a few meters away. When following the tunnel wall to the cross passage, I suddenly realised that I might be going to the wrong direction. Meanwhile, I could not longer hold my breath and had to respire, using my handkerchief as a filter. Following along the wall in the opposite direction, finally I reached the fresh air cushion which built up in front of the cross passage. That was an effect of the air streaming through the pressure relief damper, which was situated over the escape door. Happy, but coughing, my dog and I entered the safe space.

This experience was very informative for my further career as tunnel safety and ventilation designer and expert. It was a simulated emergency when I knew that my life was not threatened, where I had a good overview of the situation, knowing the positions of the lay-by and the cross passage. Nevertheless, I had problems finding my way through the smoke along a distance of only a few dozen meters. But after all, why did a system that cost Millions of EUR and was supposed to have been tested out,



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suddenly fail when it was needed?

WHERE ARE WE NOW?

A lot is written about risk analysis using theoretical personal escape models. National guidelines require escape way distances in the magnitude of hundreds of meters. My experience shows that persons may fail to reach escape ways in a tunnel filled with smoke and zero visibility even on short distances. Many car drivers don't notice the position of the escape doors, and most casualties of fire incidents die from smoke exposure.

Because short distances between escape ways are not economically feasible in most tunnels, the ability of the ventilation system to effectively control the spread of smoke is crucial. Particularly in highway tunnels with unidirectional traffic, with a longitudinal ventilation preventing smoke spread against the traffic direction, escape ways have little effect on the safety of tunnel users. However, the safety issue is more complicated in tunnels with bidirectional traffic or in unidirectional city tunnels, where congestions are supposed to happen and people may be trapped on both sides of the fire location.

Again, there are plenty of theoretical papers on tunnel ventilation issues, but in practice, for many ventilation systems we don't even know whether they will work unless an incident happens, because they are never tested thoroughly under realistic conditions. Particularly the testing of tunnel ventilation systems under random boundary conditions, without simulating the decisive driving forces like traffic, wind and buoyancy, is not really useful.

Most important of all, the complete system including power supply, control system, actuators and sensors must be taken into account, defining failure modes and safe operating states. A reliable power supply must have the highest priority. I had personally attended two smoke tests in tunnels in different countries, where the fire ventilation failed due to a breakdown of the electric power supply (let it be understood: after all systems were supposed to have been tested out).

There are plenty of examples of system failures in practice, but of course the tunnel operators and responsible designers are not keen to publish them. In real incidents, those failures may cost human lives.

A positive aspect is the effectiveness of the escape tunnel ventilation, which keeps the safe zone free of smoke. The ventilation concept of the Branisko tunnel, with fans situated in airlocks



Above: Scenario involving a moving smoke source

at both ends of the tunnel, generating an overpressure in the whole escape tunnel and an airflow in open escape doors towards the traffic tunnel, was later adopted as a basis for the Swiss guideline for ventilation of escape tunnels (ASTRA 13002) and therefore is standard in many Swiss and other European tunnels. Moreover, the proposed design was in accordance with the later published European standard EN 12101-6.

However, the escape tunnel ventilation must fit together with the escape door design. I know about many examples where people are not able to open the escape doors due to excessive pressure generated by the ventilation system, particularly when using flap doors.

Smoke tests took a step ahead. Today, we provide non toxic, non corrosive test smoke, which features many characteristics of real tunnel fires (optical density, layering effects). Most important of all, we simulate influencing boundary conditions for the longitudinal airflow in the tunnel (traffic, wind, buoyancy), thus being able to reproduce the design conditions as realistically as possible. Nevertheless, we still see smoke tests being worked out with pool fires or smoke generators producing toxic, corrosive smoke, in empty tunnels with random boundary conditions, which have nothing to do with a real incident under traffic, nor with the design conditions. And in many tunnels, no realistic smoke tests are performed at all.

CONCLUSIONS

My little adventure shows a lot about the effectiveness and reliability of fire ventilation in practice and reasonable distances of escape ways. However, the safety issues have to be addressed on a higher level.

Only short distances between escape ways are useful to save people in a tunnel fire incident when the tunnel is full with smoke. Where such short distances are not practically feasible, the spread of smoke must be effectively controlled by the ventilation system.

Many tunnels are equipped with complicated ventilation systems, which are never thoroughly tested out and as a consequence often fail in practice. Instead of that, ventilation systems should be as simple as possible, but its reliable, proper function must be ensured under all circumstances. 'Proper function' does not mean that the fan impeller is turning, but that the spread of smoke in the tunnel is effectively controlled.

Authorities are advised to define clear goals for the ventilation system to achieve for defined design conditions. Operational requirements should ensure safe, reliable function of the complete ventilation system (including control system and power supply) considering possible failure of components. Most importantly of all, achievement of goals must be proven in detail for all possible scenarios, by acceptance tests of the whole system in a real tunnel as part of project quality management. What's not tested, will not work

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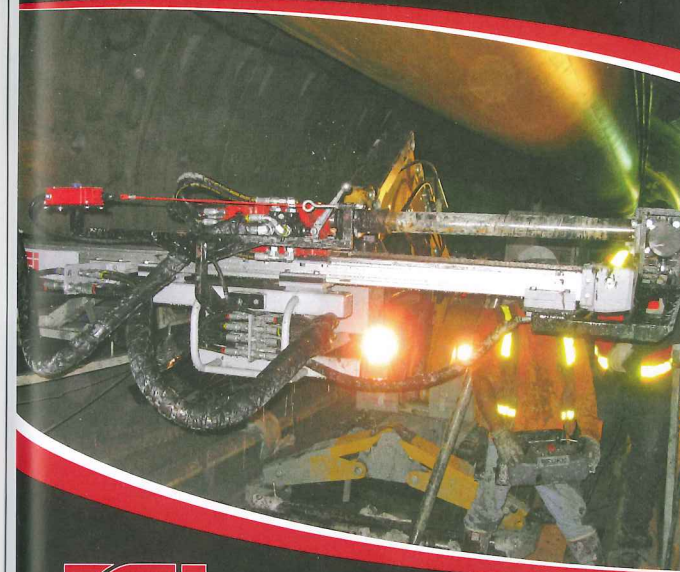


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HARDING PRIZE 2013

In this second and concluding part of his Harding Prize winning paper 'TBM crossing at the Lee Tunnel connection shaft', **David Clayton** of *Morgan Sindall* explores GRP benefits and box culvert requirements

David Clayton

David is currently a tunnel design engineer for Morgan Sindall employed as a temporary and permanent works designer at the Lee Tunnel project in East London



DUE TO the large spans and high intensity of ground loading, the concrete chamber needed to be reinforced. Steel reinforcement was unsuitable as outlined in the previous portion of the paper (see *Tunnels International* July 2013, p.31). As a result, the preferred design option for reinforcement was glass reinforced plastic (GRP) bars. GRP when excavated by the TBM disintegrates into strands, which can be handled by the slurry treatment plant and TBM slurry pumps. Furthermore, it has a comparable ultimate yield strength to traditional steel reinforcement, so it would be able to deal with the high bending and shear stresses imparted on it by the conservative ground loading model.





Above, both: The chamber in use

Left: The project's TBM being lowered down the shaft

necessitated further shear reinforcement being added in the base section but was less than the ground load condition for all of the other structural elements.

The trunnion pin design was limited by the spacing of the vertical reinforcement in the culvert wall sections. This limited the diameter of the lifting pin to 100mm. The reinforcement could not be locally cut to accommodate the lifting pins as there was very little redundancy in the system due to the aforementioned high reinforcement material safety factor and the concrete elastic behaviour criterion. The design of the trunnions was undertaken to a factor of safety 2.0 in line with current industry lifting regulations and best practice. This is in addition to the BS5950 imposed load factor of 1.6. As a result of the weight of the culvert being 22.8t (un-factored) this pushed the grade of steel required for the trunnions to S460. The high weight of the chamber determined that the 100mm diameter trunnion pins had to be grouted into their 110mm diameter seating holes, which were formed using plastic piping. The surrounding encapsulation grout was required to ensure that the very high local stress distributions could not build up due to the trunnions effectively acting as restrained cantilevers.

The back slab was cast with two holes to facilitate the rotation from its horizontal casting position to the vertical position using strops passed through the holes. This arrangement when combined with recycled tyres placed under the pivoting edge of the slab (to mobilise enough friction to stop it sliding whilst being rotated) allowed a single crane to lift the back slab into the vertical position and place it in the shaft. Once in the shaft the back slab was lined up with the culvert and the secured in position with four concrete key pins. The purpose of these pins was to ensure that as the TBM approached and the torque of the machine imparted a lateral load into the ground, the back slab would not move relative to the culvert. They, like everything else in the structure could not contain steel so they consisted of 90mm diameter concrete cylinders formed from the same mix as the remainder of the structure, inserted into 110mm diameter holes on the culvert.

Once placed on the shaft base, the chamber was filled with Thanet Sand. This was undertaken to aid short-term stability whilst filling and compaction was undertaken around the outside of the structure. Unlike the fill material everywhere else in the shaft this was plain Thanet Sand that could be easily hand excavated by the miners when they first encounter the chamber, after having entered the chamber through the TBM head intervention doors. The CBGM, as it's bound together, would have taken too long to remove from the chamber and would have added impact on the tunnelling programme.

The trunnions were grouted, which made removing them difficult after the placing of the culvert in the shaft. They had to be removed but removal had to be done very carefully so as not to damage the critical GRP reinforcement located at close vertical spacing in the outer walls. The site team cut the outside plates off the trunnions then stitch drilled around them so that they could be pulled free from inside the chamber.

To verify the lifting system, testing had to be carried out. This was completed to satisfy the LOLER and PUWER regulations as well as MVB's own lifting guidance in line with accepted best practice. The testing was subdivided into:

- The use of certified (coded) welders to weld the end plates on the trunnion pins.
- Independent non-destructive testing of critical welds on the trunnion lifting pins, in the form of dye penetration testing.
- Inspection and sign off by the designer (myself) of the chamber and slab before the lift.
- Production of a Declaration of Conformity for the Trunnion

pins as they are classified under the European Directive 2004/42/EC for lifting equipment, LOLER and PUWER.

- A ten-minute test lift on the chamber once rotated into its vertical position 100mm off ground.

CONCLUSIONS

The crossing of the shaft and the changing of the TBM tools from within the box culvert went very well. The box culvert concept achieved all of its objectives. The TBM safely transited the connection shaft and the nose cone and cutting equipment were changed in a safe environment provided by the head intervention chamber. A significant time saving on the programme was achieved and valuable experience gained on the crossing of shafts affected by contamination. The author learned a great deal from the design and sequencing of the works and is proud of how the system and the GRP reinforced intervention chamber in particular performed. In hindsight, the only item the author would have changed was the pipework arrangement, which became blocked, but this thankfully did not significantly affect the crossing, only slowing the initial shaft emptying

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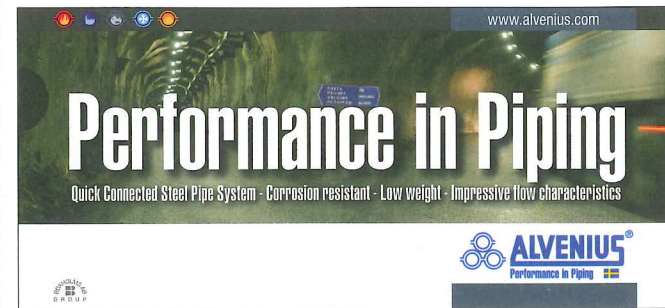
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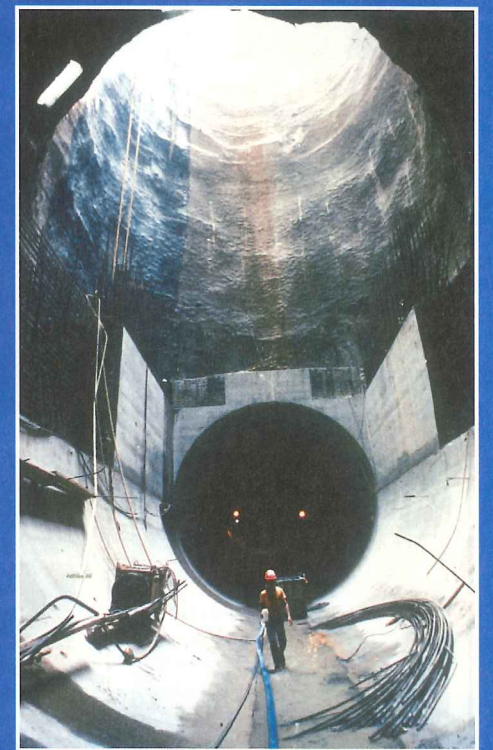
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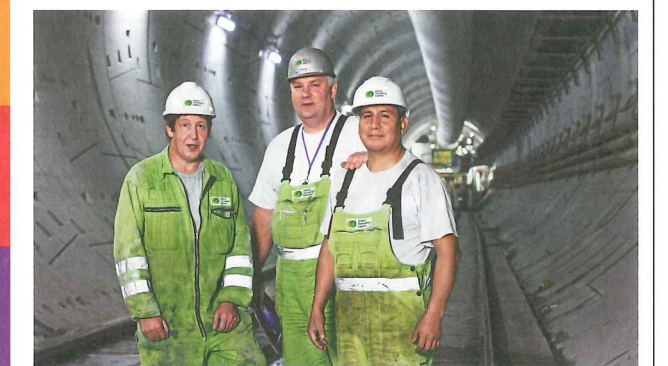
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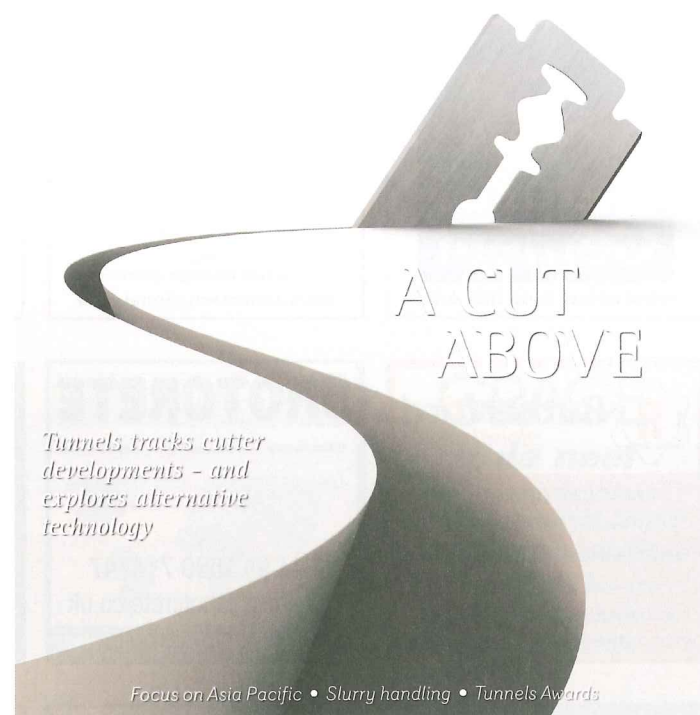
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What's on

2013

ISARC/WMC 2013

11-15 August 2013
Montreal, Quebec, Canada
The 30th International Symposium on Automation and Robotics in Construction, Mining & Petroleum Industries (ISARC) is being held in conjunction with the 23rd World Mining Congress (WMC). Both conferences will sponsor a joint trade show.
www.isarc2013.org
www.wmc-expo2013.org

18th ICSMGE

2-6 September 2013
Paris, France
The 18th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE) will have a new format with the first two days devoted to plenary sessions and the following days devoted to discussion of papers and workshops from the committees.
www.issmge2013.org

The 15th International Symposium on Aerodynamics, Ventilation & Fire in Tunnels

18-20 September 2013
Barcelona, Spain
The Symposium, celebrating its 40th year, is focused towards knowledge transfer on aerodynamics, ventilation and fire in tunnels.
www.bhrconferences.com

Bauma Africa

18-21 September 2013
Johannesburgh, Africa
The massive construction show holds its first event in the African continent, focusing on all sectors and facets of the construction industry.
www.bauma-africa.com

SITCE 2013

7-10 October 2013
Singapore
The inaugural SITCE is a platform for urban land transport professionals worldwide to meet and discuss ways to shift the transport focus to people. The biennial SITCE is one of the first initiatives by the UITP Centre for Transport Excellence for the Asia-Pacific region.
www.sitce.org

www.tunnelonline.info

62nd Geomechanics Colloquy

9-11 October 2013
Salzburg, Austria
The annual Colloquium of the OeGG. This year's topics include: power water conduits, special measures in soft ground, and international large projects.
www.oegg.at

ExpoTunnel

17-19 October 2013
Bologna, Italy
The newly-established exhibition will also host the Italian Tunnelling Society congress entitled "Tunnelling and Underground Space for European Development."
www.expotunnel.it

Southern Railway Link Conference

Koraln and Semmering tunnels
21 November 2013
Leoben, Austria
The Southern Railway SESSION is a forum to present experiences and discuss case studies to the above tunnels major projects and other projects along the Southern Railway.
www.suedbahntagung.at/index.php

Stuva Conference

27-29 November 2013
Stuttgart, Germany
The bi-annual conference of the Stuva organisation heads to Stuttgart.
www.stuva.de/en

2014

CONEXPO

4-8 March 2014
Las Vegas, USA
Held every three years, the exposition showcases the latest construction equipment, products, services and technologies. The show will be held at the Las Vegas convention centre.
www.conexpoconagg.com

Eurasia Rail

6-8 March 2014
Istanbul, Turkey
The 4th International Rolling Stock, Infrastructure and Logistics Expo features a tunnel construction section. By 2023, Turkey's Ministry of Transport is planning to build more than 11,000 km of rail track. International pavilions are

on show from Poland, France, Germany, Russian Federation, Czech Republic, the United Kingdom and Republic of China.
www.eurasiarail.eu

ISTSS

12-14 March 2014
Marseille, France
The 6th International Symposium on Tunnel Safety and Security will discuss current practice and emerging trends and research in the field of tunnel safety and security.
www.istss.se

Samoter

8-11 May 2014
Verona, Italy
This trade show dedicated to earth moving, site and construction machinery is held every three years. In 2011, the exhibition attracted 98,000 visitors and more than 900 exhibitors (of which almost 30 per cent were international).
www.samoter.it

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. Events are hosted at the Institution of Civil Engineers in London from 5.30pm every third Thursday of the month.

Thames Tideway Tunnels

19 September 2013
After more than two years of public consultation on Thames Water's proposals, the development consent application was submitted to the Planning Inspectorate on 28 February. The presentation will include background on the sewage problems and the proposed solution; an update on the project development and design for tender; progress on the development consent application; an outline of the technical challenges faced; the proposed delivery route for the construction; and the latest situation on procurement.

London Underground turns 150

23 October 2013
A special presentation in honour of the 150th anniversary of LU operations.

National grid cable tunnels

21 November 2013
A report on the project, which comprises 33km of 3m and 4m diameter tunnels across London. John Trounson, National Grid Stephen Meadowcroft, Costain.

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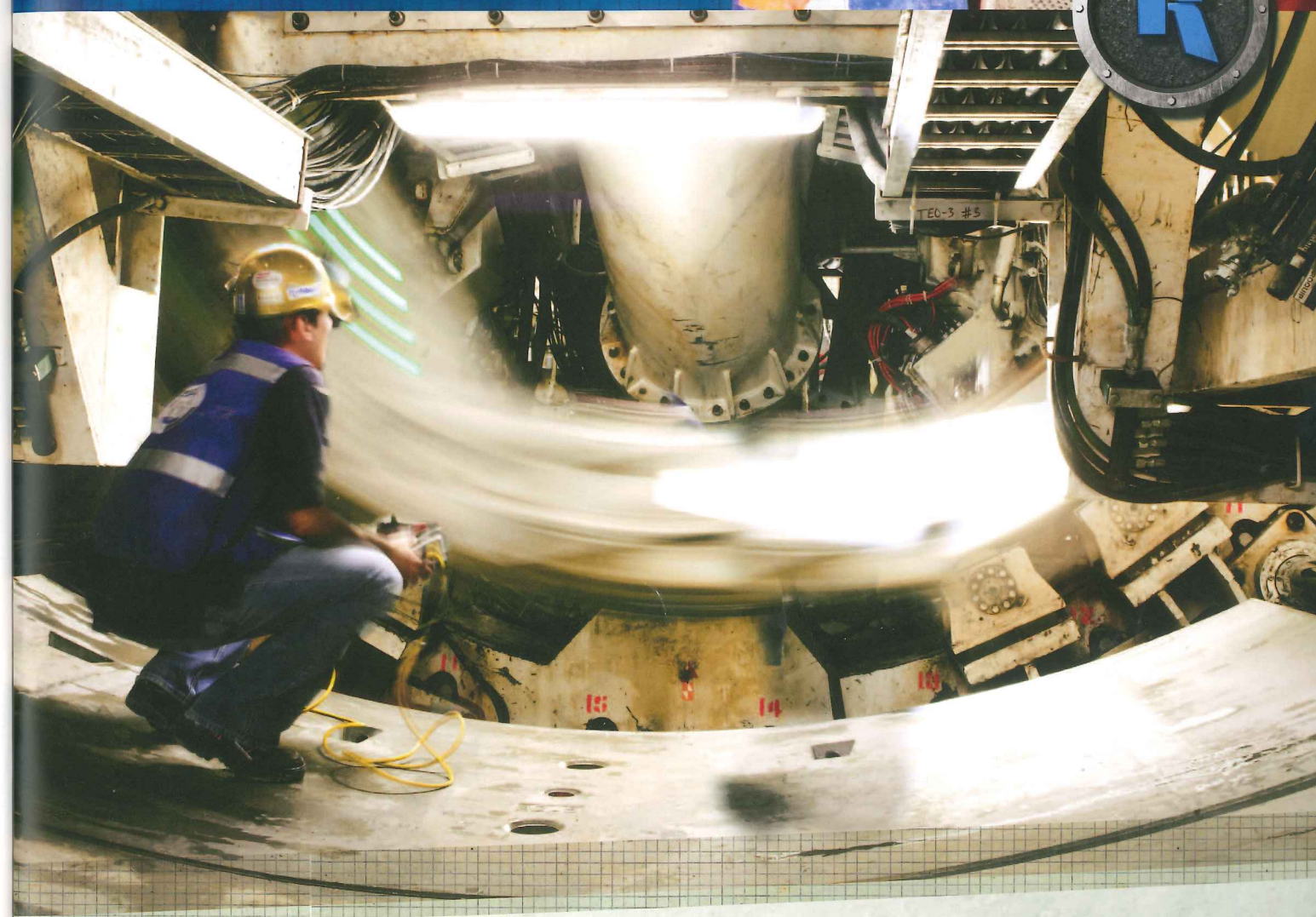
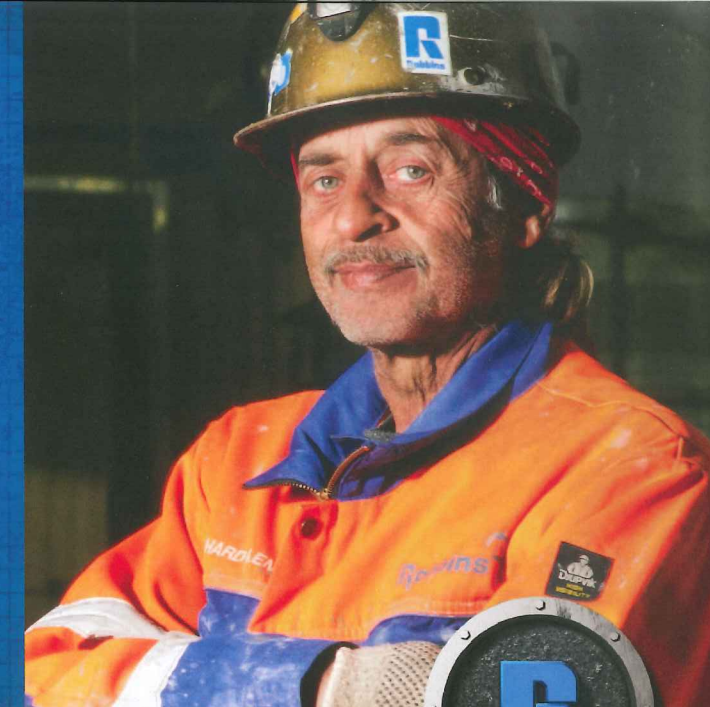
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