

DECEMBER 2010

tunnels & tunnelling

INTERNATIONAL



42



30

Special report: Asian subcontinent

T&TI explores the Indian tunnelling market

Technical: Ventilation

New standards of road ventilation, jet fan performance modelling and provisioning for economy, upgrades and new demands

WWW.TUNNELSONLINE.INFO



Rohtang ready to rock

T&TI investigates surveying and monitoring procedures

TUNNEL WITH CONFIDENCE START TO FINISH...

Since 1972, our highest priority has been safety in the tunnel. We believe that innovation, efficient design and manufacturing excellence are all driven by a "safety-first" culture, leading to superior results.

In 2008, Lovat combined its underground expertise with the resources of Caterpillar, a company that understands large scale manufacturing and the importance of research and development.

Together, we have increased our commitment to the tunnelling industry, while continuing to provide first class services and customer satisfaction.

Caterpillar is the world's leading manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines and leading services provider through Financial Services, Caterpillar Remanufacturing Services, Caterpillar Logistics Services and Progress Rail Services. For more information on Caterpillar, Visit CAT.COM



AND BEYOND

www.lovat.com

© LOVAT Inc., 2010

Registered ISO 9001: 2000
Certificate No. 0020366

CAT, CATERPILLAR, LOVAT, their respective logos, "Caterpillar Yellow" and the "Power Edge" trade dress, as well as corporate and product identity used herein, are trademarks of Caterpillar and may not be used without permission.

LOVAT
A Caterpillar Company



comment

Capitalising on competition

There is no denying it, tunnelling is a cut-throat business. One TBM manufacturer put it to me: "There is always some bastard willing to do it for one per cent less than you. And if you win the job then you're that bastard."

Clients are working hard to play on this competition and encourage it as it can result in cheaper tunnels. But some tunnellers will be wondering if cheaper tunnels are good or bad news for the projects and the industry.

In Singapore, major tunnelling client the Land Transport Authority (LTA) has this mastered. For the recent metro projects it awarded the contracts on a 70/30 split, price and experience. Ahead of the tender it went on a global marketing tour to encourage more contractors to bid. And the efforts paid off. On one contract the winning tender was more than SGD 200M (USD 150M approx.) cheaper than the closest competitor, saving the LTA about 40 per cent of the contract cost.

The LTA is now looking at buying its own TBMs. The contracts were tendered last month and will be awarded on an 80/20 split, almost guaranteeing the lowest bidder the contract. Big savings are sure to follow for the client.

On the Crossrail job in London the TBM giants are lobbying Crossrail to send the contracts their way. Although it will be the contractor who awards the purchase contract, the manufacturers are promising extra back-up, services and support to the jobs in an effort to get ahead of the competition. The contractors themselves have already made their bids and are awaiting response.

Simple economic theory says that lower costs will lead to more tunnelling. But some worry about what the impact will be on the industry - even some at the LTA.

It is not the case that the cheapest tender is always from the least experienced contractor. Major tunnelling contractors are winning projects, even when the client is motivated mainly by price. But if price is the main driver, and a good prequalification structure isn't in place, it is possible that inexperienced contractors can win projects by underestimating the costs. This would leave an inexperienced contractor quickly looking for ways of saving money on the project as the true costs become apparent. Indeed, experienced contractors could make (and have made) the same mistake of under-pricing if under strong pressure to cut costs to compete. Ultimately the project could suffer.

The LTA, at least, has recognised the risk of getting an inexperienced contractor and has developed a clever legal document that puts some of the project liability on the machine manufacturer, in a move that it hopes will pressure the manufacturer into ensuring the contractor keeps on the straight and narrow. This Deed of Collateral Warranty is going to be a headache for some TBM suppliers but could be good news for contractors. T&T will be digging into this early in the New Year.

Tunnellers can afford to make a loss on the occasional project, even if they don't like to. But not many companies can sustain losses on multiple projects. Aggressive competition will lead to more companies facing losses and perhaps the consolidation of tunnelling firms.

As 2010 draws to a close there is just one thing left for me to do and that's to wish you all a merry Christmas and a successful New Year.

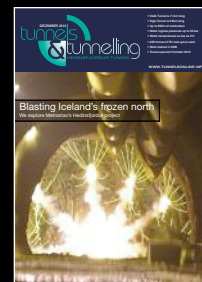
Jon Young

contents



On the cover

A detailed look at surveying and monitoring at Rohtang (page 22)



In the supplement

T&T explores the Hedinsfjordur project in Iceland

NEWS

- 5 **WORLD NEWS**
- 12 **BUSINESS NEWS**
- 14 **NEWS IN DEPTH**

SPECIAL REPORT: ASIAN SUBCONTINENT

- 16 **MARKET REVIEW**
Subcontinent weathers the storms
- 19 **DELHI METRO**
Capital metro expansion
- 22 **ROHTANG PASS**
Monitoring Rohtang

TECHNICAL REVIEW: SURVEYING AND GUIDANCE

- 29 **VENTILATION DEVELOPMENTS**
Winds of change for tunnel environment
- 31 **AIR QUALITY STANDARDS**
Breath of fresh air
- 33 **COMPUTATIONAL FLUID DYNAMICS**
Jet fans: Removing non-conservatism from the CFD modelling

LEGAL

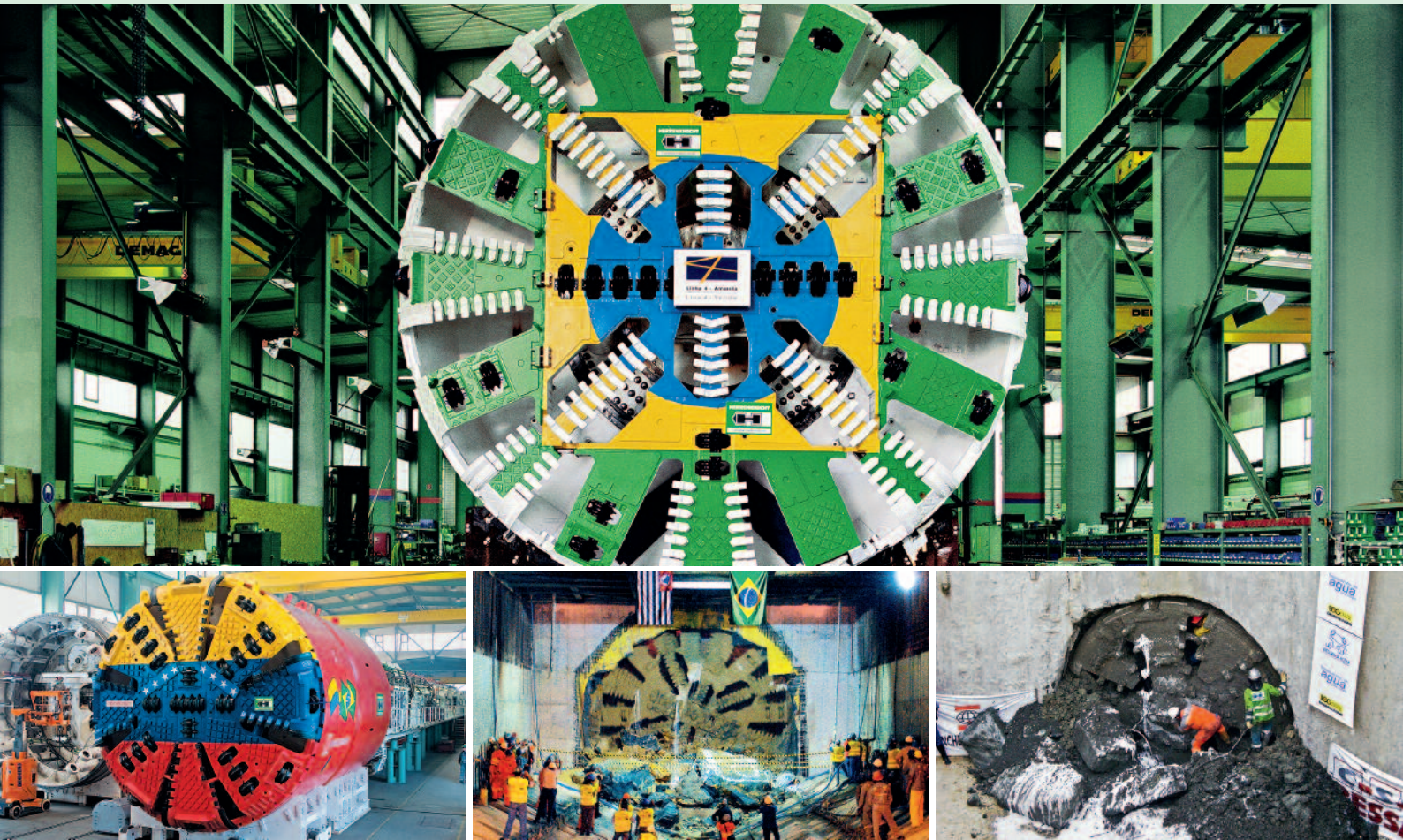
- 37 **GROUND CONDITIONS & RISK**
There must be a better way
- 42 **CHANGE**
Change: Project and Legal Perspectives

INDEX

- 47 **T&T INDEX 2010**

DIRECTORY

- 50 **PRODUCT MARKETPLACE**
- 51 **RECRUITMENT**
- 52 **BUSINESS DIRECTORY**
- 54 **BTS CORPORATE MEMBERS**
- 57 **DATES AND EVENTS**
- 58 **CONTACTS**



BUILDING THE FUTURE TOGETHER.

As the only company worldwide, Herrenknecht delivers cutting-edge tunnel boring machines for all ground conditions and in all diameters (0.10–19m). Our tailor-made machines create supply and disposal tunnels as well as efficient transport infrastructures. Our tunnel boring machines have successfully excavated more than 650 kilometers of subway tunnels, 155 kilometers of road tunnels and 365 kilometers of railway tunnels worldwide – including the Gotthard Base Tunnel which, with a length of 2x 57 kilometers, will be the longest railway tunnel in the world. A team of innovative specialists from 65 Herrenknecht subsidiaries and associated companies working in related fields offer integrated solutions around tunnel construction with project-specific equipment and service packages – close to the project site and the customers.

Herrenknecht know-how and technology is also in demand in South America. At the present time, 4 EPB Shields from Herrenknecht, moulds from Herrenknecht Formwork and rail vehicles from MSD are involved in the extension of the subway network in the Venezuelan capital Caracas. Tunnelling in subway line 4 in Sao Paulo, Brazil has already been completed: The EPB Shield S-336 (Ø 9.46m) successfully reached its target after tunnelling 6.4 kilometers at the end of 2009. Herrenknecht machines have also been in use in a sewage project in the Columbian capital Bogotá. There, a total of 6 EPB Shields are producing 4 sewage collectors which will relieve the rivers and channel the sewage into a newly-built sewage treatment plant.

Herrenknecht AG
D-77963 Schwanau
Phone + 49 7824 302-0
Fax + 49 7824 3403
marketing@herrenknecht.com
www.herrenknecht.com

Herrenknecht Latin America
DBR-04717-912 São Paulo
Phone+55 11 51804400
Fax +55 11 51804400
altstadt.juan@herrenknecht.com.br
vernier.javier@herrenknecht.de
sucri.sebastian@herrenknecht.com



NY plans Delaware Aqueduct bypass

USA

A three-mile (4.8-km) bypass tunnel will be constructed to repair the leaking Delaware Aqueduct, according to a design plan released by New York City's Department of Environmental Protection (DEP) on 19 November.

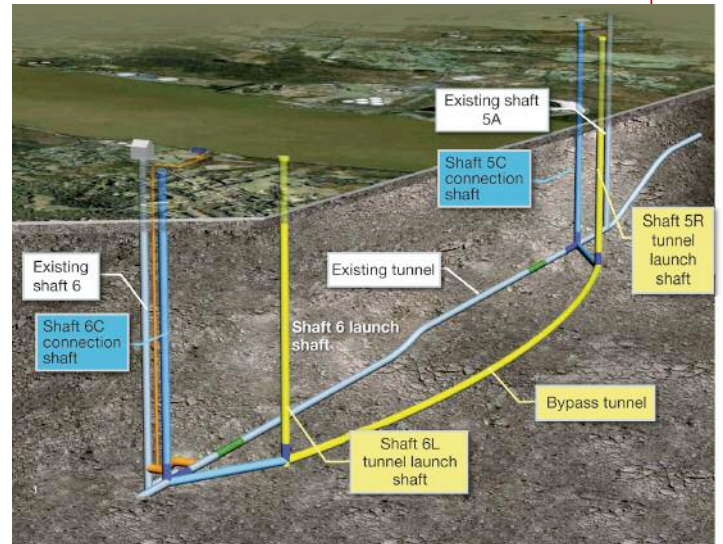
Under the plan, the USD 1.2bn new bypass tunnel will be built around a portion of the aqueduct experiencing the most significant leakages and parts of the aqueduct's concrete liner will be repaired. The alignment will run east from Newburgh, under the Hudson River, to Wappinger.

The 85-mile (136.8km) aqueduct varies in diameter from 13.5 to

19.5ft (4.1 to 5.9m) and runs as deep as 1,500ft (457m). It was constructed by drill and blast in 1944 and in most areas it is lined only with unreinforced concrete, though a steel reinforcement liner had been added later in areas of weaker rock.

DEP has called for construction on four access shafts ranging from 700 to 900ft (213 to 274m) deep with 15 to 20ft (4.6 to 6m) diameters to begin in 2013. Tunnelling, to be performed by a 22ft (6.7m) diameter TBM, is expected to start in 2015.

Equipment purchasing and contract document preparation, including for the bypass tunnel, are underway now.



Breakthrough in British Columbia

CANADA

A second TBM has achieved breakthrough at Seymour Capilano Water Filtration Project, three months ahead of the revised schedule. The 3.8m diameter Robbins TBMs have spent two years tunnelling, excluding an 18-month suspension due to a dispute over ground conditions with the original contractor. The second contractor was the Seymour Capilano Partnership (SCP) JV consisting of Frontier-Kemper Constructors, Aecon Constructors and JF Shea.

Metro Vancouver required the construction of twin 7.2km tunnels through difficult granitic and metavolcanic rock at rates reaching 29m per day. Overburden reached 600m at maximum. Faulting and shear zones were encountered and overcome with a ground support program.

Ground varied from Class I to Class V with rock left bare for the former but supported by rock bolts, wire mesh and channel

straps for the latter. Steel sets were also used every 760mm in poor rock conditions.

"I think we've proven here that you can tunnel through the hard granitic rock of British Columbia, even with all its quirks and stress releases. We've shown that this is an effective alternative to drill and blast," said Serge Moalli, project manager of Frontier-Kemper.

The breakthrough struck the first tunnel at an angle at the intended location for a chamber to facilitate drilling of the 270m deep Capilano shaft, which will take two years in total.

The tunnels are intended to transfer either raw or treated water to a new filtration plant. When finished, it will clean 1.8bn litres of water per day to federal standards for drinking water.

"We are quite pleased with the breakthrough. The success of this project can be attributed to having an excellent crew of knowledgeable people, good pre-planning of the work and very good TBMs," Moalli added.

Odebrecht wins contract scrap

PANAMA

Odebrecht has been awarded the contract to build Panama City's first subway line, the 14km Line 1. The bidding (announced in T&T November 2010 p19) was between Consortium Linea Uno lead by Constructora Norberto Odebrecht (CNO) and Grupo Italiano Metro Panama lead by Impregilo. These were the only two bids made for the project by the deadline on 31 August 2010.

The group headed by

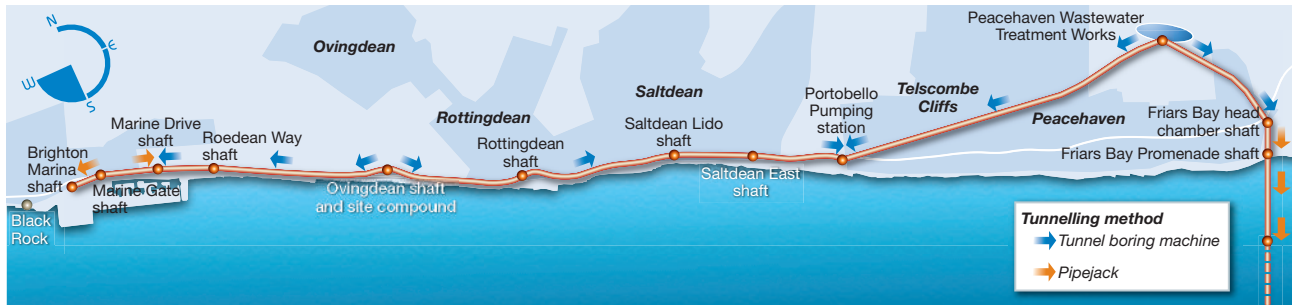
Odebrecht has its bid rated at 917 points, compared to the 708 gained by the competition. Odebrecht said it presented the best value for money as well as the best technical bid.

The project will receive an investment of USD 1.5bn and is anticipated to take three years and two months to complete. It is anticipated that the project will benefit up to one million of the total 3.4 million population of Panama. The government is currently studying the possibility of a second line.

News in brief

▼ **Stillwater to expand**
Stillwater Mining Company has announced that two projects, the 'Blitz' and the 'Graham Creek', will result in the extension of the complex in southern Montana, United States. The Graham Creek project will drive out a further

7900 feet (2400m) to the west in order to determine the platinum group minerals (PGM) stock. The resident TBM, last used on the site about 10 years ago, will be used. The Blitz project will extend some 13,500 feet (4100m) to the east and is intended to examine PGM levels there.



First breakthrough on Brighton sewer project

GREAT BRITAIN

Boring for the new sewer tunnel between Ovingdean and Marine Drive in Brighton saw breakthrough after 119 days.

Work started in June by 4Delivery, a JV consisting of Costain, MWH and United Utilities. Excavation was carried out by a 62-t, 2.44m outer diameter TBM, named 'Alice' by local school children.

The bore was 1783m long through chalk, excavated at a rate

of a metre every 10 minutes.

"A great cheer went up at the reception shaft when her teeth appeared through the concrete wall. It was truly a celebratory moment for the engineers, miners and the management team alike," said Julian Smith, project manager for Southern Water.

The TBM will be returned to Ovingdean to begin another bore towards the under-construction Portobello Pumping Station in Telscombe to the east.

"This is a fantastic achievement

by the team," said 4Delivery Infrastructure project manager for the scheme, Craig Reade.

"The first tunnel breakthrough is a significant milestone in this complex project and I am pleased to share with our client the recognition of the site team's hard work and effort since the start of the project over a year ago."

Another TBM ('Hollyblue') is boring from the wastewater treatment works at Peacehaven to the pumping station at Portobello. This TBM will then also be

returned to begin excavation of a tunnel between Peacehaven and Friars Bay.

Pipejacking will be used to lay remaining sewers.

Southern Water's GBP 300M (USD 472.9M) 'Cleaner Seas for Sussex' project consists of approximately 11km of new sewers (9km by Alice and Hollyblue) as well as a new wastewater treatment works and a sludge-recycling centre (see feature coverage in *T&T* September 2010 p23).

Record immersed tube tunnel contract

CHINA

A joint venture group has been awarded the contract for construction of the tunnel and artificial islands of the Hong Kong-Zhuhai-Macao Bridge (HZMB), formerly known as the Hong Kong-Zhuhai-Macao Bridge North Lantau Highway Connection.

The contracting group consists of Aecom, Shanghai Urban Construction, China Highway Planning and Design Institute, Shanghai Tunnel Engineering & Rail Transit Design and Research Institute and CCCC Fourth Harbour Engineering Investigation and Design Institute.

The contract terms required the construction of a 6.7km immersed tube tunnel as a portion of the total 29.6km of the HZMB. This will be the longest

immersed tube tunnel in the world, surpassing the Oresund tunnel, which reached a length of 4km when completed in 2000. The contracting group hopes to begin construction this year with a view to completion by 2016 when the whole project is due.

The preliminary design and site investigation was by a JV led by China Highway Planning and Design Institute Consultants with COWI, Ove Arup & Partners Hong Kong, Shanghai Tunnel Engineering & Rail Transit Design & Research Institute, and CCCC First Harbour Consultants.

Technical difficulties have been assessed as 'world-class' and include long distance ventilation with safety design, prefabrication and marine transportation of huge tube sections and joining of the sections under high water pressure.

Survey finds support for Alaskan Way bore

USA

The majority of people in and around Seattle support replacing the SR99 Alaskan Way Viaduct with a bored tunnel, a survey has found. On learning key project details, 62 per cent of 1,000 registered voters supported a tunnel.

"This survey helped us understand how effective our outreach efforts have been so far," said Paula Hammond, secretary of the Washington State Department of Transportation (WSDOT).

Ron Paananean, WSDOT's Alaskan Way Viaduct and Seawall Replacement Program administrator added, "Replacing the viaduct has long been a controversial project, but this survey shows that after learning information about the project,

people think the proposed bored tunnel is the right solution. In addition to strong support for the bored tunnel, there was a significant majority that support maintaining or increasing capacity in the SR99 corridor."

Meanwhile, Washington state governor Chris Gregoire announced that both bids submitted to design and build the SR99 bored tunnel were at or below the contract price limit; both were from two teams of national and international firms. Representatives from the WSDOT, Seattle Dept of Transportation, industry experts and the programme's Strategic Technical Advisory Team will take part in proposal evaluation on a points credit system. The total cost of the tunnels and associated works is estimated at USD 1.96bn.

Lower Mill Creek contract awarded

USA

Black & Veatch announced on 8 November that it has been awarded the design contract for the Lower Mill Creek Tunnel in Cincinnati, Ohio.

The proposed USD 244M tunnel will be 1.2-miles (1.9km) long and 30ft (9.1m) in diameter. It is expected to have a capacity of 33M US gallons (150M litres).

The tunnel will be part of 'Project Groundwork', which,

valued at approximately USD 3.3bn, was laid out to reduce combined sewer overflows in Cincinnati by 85 per cent. Currently these exit to local waterways including the Ohio River.

Geotechnical investigations have begun to find the optimal route and depth of the tunnel. Detailed design is expected to begin in 2011. Construction should be completed in 2018.

Black & Veatch presented the thinking behind tunnel usage to

solve the sewage problem:

- Less energy use than traditional conveyance methods.

The tunnels are largely built to enable gravity to pull water across long distances to a central treatment facility, reducing energy consumption.

- Sewer overflows can be held in the tunnel system until 'off-peak' times, providing operational flexibility.

- Tunnels are located hundreds of feet below ground, providing flexibility for future

redevelopment at ground level.

- Tunnels have minimal maintenance expenses when compared with conventional sewer technology.

The Metropolitan Sewer District of Greater Cincinnati has explored alternatives to tunnelling, including stormwater retention basins, source control solutions, rain gardens and stream separations.

Black & Veatch is also contracted to design the pumping station for moving wastewater from the tunnel to treatment works.

Construction starts on Tuen Mun sewer

HONG KONG

Chun Wo Development Holdings (a Hong Kong construction company founded in 1968) announced on 7 November that it has begun work on the HKD 710M (USD 91M) Western Trunk Sewerage Project in Tuen Mun, Hong Kong.

The project aims to increase the capacity of the sewer collection system by building a 6km long trunk sewer and a pumping station.

A remote-controlled TBM was the chosen method to bore the necessary 4km of pipejacked tunnel as it has the smallest impact on residents. It has not been foreseen that any road excavation will be necessary.

2.5km of the pipejacked sewer will be in DN1800 concrete gravity pipe, with 1.5km as a DN1400 sleeve pipe for twin hdpe rising mains of DN900. The remaining 2km of sewer will be laid as a twin-cell box culvert.

Clement Kwok, the managing director of Chun Wo, said, "we are pleased to become the main contractor of the Tuen Mun Western Trunk Sewerage Project. In order to mitigate the impact to the local residents, we have

purchased two new TBMs for laying the underground pipes. We hope the technology can be more widely applied in Hong Kong in the future to preserve the quality of living environment for local residents while we push ahead with city development projects."

The project runs alongside a series of similar endeavours. The HKD 20bn (USD 2.6bn) Harbour Area Treatment Scheme (HATS) of Victoria Harbour transfers waste through a deep tunnel system for treatment at a central plant on Stonecutters Island. Sewerage has been a priority for Hong Kong since 1989 and with the later release of the '16 Sewerage Master Plans' by the Environment Protection Department.

The need for sewer expansion stems from Hong Kong's rapidly growing population. Since World War II, the population has increased approximately 12 times, to seven million. Some 93 per cent of the inhabitants are served by the current sewer system, which has a total length of approximately 1600km.

The Tuen Mun project will be completed by 2014, providing increased capacity for future development.

Spadina awarded

CANADA

The Toronto Transit Commission (TTC) awarded a CAD 279M (USD 276M) contract to Aecon, the first of two for tunnelling the 8.6km Toronto-York Spadina Subway extension.

For this first contract, the southern package from Downsview to Finch West station, a joint venture of Aecon/McNally Construction/Kiewit Construction will bore the 2.6km of twin running tunnels that will extend the Spadina line and construct the new Sheppard West station.

Construction for the extension will start in December, and Don Brophy, senior vice president of Aecon's infrastructure division, confirmed tunnelling work will start in March 2011.

The second contract, the northern package, includes NATM plus compensation grouting to construct a double ended pocket track housing structure for trains to turn at peak time. It is expected to go to tender on 15 December. All contractors were prequalified in early 2010.

TTC has procured four Lovat EPB machines of 6.12m diameter, in advance of tendering the contracts.

News in brief

▼ Copenhagen Circle construction contract

A Salini-Technimont-Seli JV has won a contract to construct 15.5km of twin tunnels and 17 stations for Copenhagen's Metro City Circle Line. 14.9km of the twin tunnels will be driven by TBM at 4.9m id, primarily in limestone. In variable sections normal excavation and sprayed concrete lining will be used, plus some cut-and-cover work. Completion is due in 2018.

▼ Crossrail fire

One of London's Crossrail construction sites was ablaze on 18 November with two fire engines in attendance. A site worker told *T&T* an electrical fire was started when water flooded into a site building on the Lindsey Street construction site, part of the development for the new Farringdon Station. The fire was apparent at 9am until firefighters brought the blaze under control in 20 minutes.

Blanka aftermath means tentative progress

CZECH REPUBLIC

Following the Blanka Tunnel collapse in the Czech Republic capital of Prague's ring road project (T&TI World News August p5 and In Depth p14), construction in both tunnel tubes is progressing tentatively, and therefore slowly, in consideration of the situation in which there are still several 'loose ends'.

One matter that has been settled is the infringement of two Mining Authority rules by the main contractor Metrostav (MTS), for which the state mining authority fined it one million Czech Koruny (USD 52 000). These were for a discrepancy in the construction method statement in accordance with the valid design, and for not fully covering connection detailing with sprayed concrete.

Metrostav admitted its fault in both respects which involved the demolition of temporary inside walls, as part of the SEM/NATM construction procedure, and the shotcreting of connection areas between the initial linings of the side drifts and the top heading.

Although a source in Metrostav believes that there were some

shortcomings in the tunnel construction design, MTS decided not to fight the fine and accepted it, in order, said the source, to allow restarting and continuation of the works in the earliest possible time.

Work restarted in the south tube on 27 October and in the north tube (where the collapse occurred) on 15 November, with excavation from the alternative portal as a counter drive. The District Mining Authority of Kladno had halted all construction works at the project, apart from essential safety provision, until it was satisfied that safe work could proceed.

Metrostav anticipates no additional fines on itself, although, as suspected by Tunnels & Tunnelling International (T&TI Comment August p3), other parties may be involved. The Prague City Magistrate is currently investigating the responsibilities of the designer and the client (the City) itself.

Our source cites other 'expert opinions', brought in by the Client, that list other reasons for the collapse including changed geological conditions, possible design shortcomings, imperfect



Above: Surface situation at the time of the collapse in the north tube of the Blanka Tunnel

details in respect of full concrete spraying (shotcreting) of the initial lining including demolition of temporary walls (see above), and insufficient supervision of the works by the client. The authorities consulted are believed to include Amberg and Bung.

Ironically, the Mining Authority only inspected the site one week before the collapse, but during such visits it tends to concentrate on compliance with its regulations rather than structural design matters over which it has no direct function. It made no

comments on the progress of work. The Authority's rules have been designed for mining situations which some say are difficult to apply in modern tunnelling methods such as NATM and TBM drives.

Before the collapse Metrostav says that the works were 2-3 months ahead of schedule. Although most of this advantage was lost due to the works stoppage after the collapse, MTS believes that the project deadline will still be met as work is now progressing, albeit slowly.

Excellence in mine construction

ROMANIA

Major mining company Rio Tinto will be investing CAD 10M (USD 9.97M) over a five year period in the new Rio Tinto Centre for Underground Mine Construction (RTC-UMC) at the Centre for Mining Innovation (CEMI) in Sudbury, Ontario, Canada.

The centre is focusing on mechanised excavation including a shaft boring system (SBS) and tunnel boring system (TBS). Rio Tinto has selected CEMI as the agent for collaborative research

leadership in support of high-speed construction for underground mines. His is the fifth long-term research centre to be established by Rio Tinto.

The research programme at RTC-UMC will cover ground and machine performance using prototype test sites instrumented to study ground characterisation techniques and to develop innovative support techniques for high-speed construction in highly stressed ground and at great depths.

Researchers will work with a global network to study prototype

testing wherever the TBS and SBS are employed. In 2012, as part of the programme there will be a full-scale performance verification trial of the first of three new underground excavation systems at Northparkes' copper and gold mine in New South Wales, Australia.

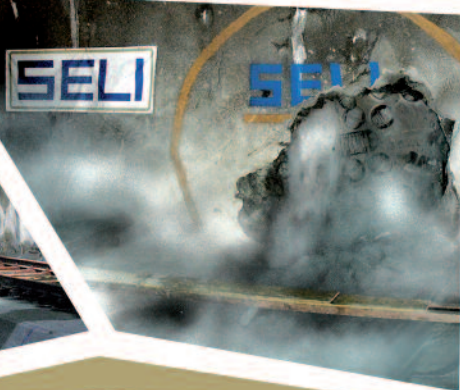
John McGagh, head of innovation at Rio Tinto stated, "In order to satisfy the increasing global demand for minerals Rio Tinto is seeking a step change improvement in the construction of the next generation of large underground mines."

News in brief

Channel Tunnel anniversary

For those of us who are now feeling our age, it will do little good to be reminded that it was just over 20 years ago when miners Graham Fagg from England and Philippe Cozette from France shook hands through the breakthrough hole of the Channel Tunnel service bore, forming the first 'dry land' link between Britain and continental Europe in many thousands of years. Ironically celebratory drinks were allowed to be 'wet' for the first time ever on site.

Boring through Future



3rd November 2011

Brennero Exploratory and Service Tunnel Breakthrough



www.selitunnel.com

Drug barons turn tunnel boffs

USA

A second San Diego drug tunnel has been detected and closed down by the local authorities. The operation, which took place on Thursday 25 November, resulted in a total of eight suspects being detained in Mexico and the USA, as well as the seizure of over 20t of marijuana, said the US Drug Enforcement Administration (DEA).

The tunnel stretches for almost half a mile (approx. 0.8km) from

the Otay Mesa industrial complex in southern San Diego to Tijuana, Mexico. The tunnel has an estimated maximum overburden of 90 feet (27m). The walls were fitted with wooden and cinderblock supports. The entire passage benefited from advanced rail works as well as electrical and ventilation systems.

Tractor-trailer trucks carried out supply to the portals, of which two were discovered on the San Diego side. The portals were located out of sight in two warehouses

approximately 800 feet (approx. 245m) apart.

Supply of the tunnels proved to be the Achilles heel of the trafficking operation. The DEA has revealed that agents flagged up the suspicious parking of one of the trucks outside a warehouse during routine surveillance. The truck was then halted at a traffic checkpoint in Temecula, USA and relieved of its 27,600lb (approx. 12,500kg) cargo of marijuana.

"This discovery again shows the cartels' growing desperation in the

face of beefed up border security and the costly extremes these organisations are trying in an effort to avoid detection," said Miguel Unzueta, special agent in charge of security investigations in San Diego. "Once again, we've thwarted their scheme and I predict you'll see more such successes in the future."

In the last four years, more than 75 smuggling tunnels have been detected traversing the border, most of which emerge in California and Arizona.

Bi-County breakthrough

USA

The USD 168M Bi-County Water Tunnel project in Maryland achieved breakthrough at 8am (EST) on 23 November.

The tunnel will run for 5.3 miles (8.5km) from the main access shaft near Connecticut Avenue to the Stoneybrook/Beach Drive shaft, and lies about 200 ft (approx. 60m) below the surface.

The tunnel, designed by Black & Veatch and constructed by a Renda/Southland/SAK JV, will house an 84in (2.1m) diameter water main, connecting the two existing 96in (2.4m) mains.

Excavation was carried out by a 10ft (3.1m) in diameter TBM. The cutter head was arrayed with 21 carbide cutting heads of 17in (43.2cm) each. A substation was

built at the Connecticut Avenue site to provide electricity for the TBM. To meet project requirements, the 17-year-old TBM has been boosted from 800 to 1200 horsepower.

In order to create space for the subterranean assembly of the machine, workers used explosives to excavate two 150-ft (50-m) tunnels from the Connecticut Avenue shaft; the last blast occurring on 23 June.

The cutterhead will be transported back to the main access shaft near Connecticut Avenue by truck while the rest of the setup will be reversed through the tunnel. The TBM will then bore 4.5 miles (7.2km) westwards to the Tuckerman Lane shaft. This process could take two months.

Tunnelling began on 23 July and completion is expected in 2013.

Breakthrough on Victoria Park Tunnel

NEW ZEALAND

A breakthrough was achieved on the New Zealand Transport Agency's Victoria Park Tunnel project in Auckland, New Zealand on 29 November.

A digger scraped away the last of the earthen wall that divided two cut trenches some 12 months after excavation began in November 2009.

Final completion is scheduled for 2012, two years earlier than the initial estimate.

The tunnel has been constructed by cut and cover. The concrete roof will be covered with topsoil upon completion so that the area may be used as a public

space. In this way the tunnel has not cost the community a park.

The New Zealand Government has designated the tunnel as one of the seven Roads of National Significance, which is a means of signifying priority projects to the Transport Agency.

The V-Formation consortium, a joint venture of Fletcher, Higgins, Beca and Parsons Brinckerhoff, is handling construction of the NZD-406M (USD-305M) project.

Construction work has seen the usual blockaded roads associated with such ventures but also, more unusually, the transportation of a 125-year-old hotel 40m up the road (see T&T September p6).

News in brief

Impregilo to complete Abu Dhabi sewer

Italian contractor Impregilo has won the contract for the third and final lot of Abu Dhabi's Strategic Tunnel Enhancement Programme (STEP) for the Abu Dhabi Sewerage Services Co (ADSSC). The sewer is seven metres in diameter and this lot is 10km long out of a total of 40km. Impregilo

is already constructing the first lot of 15km. The contract value is about USD 200M.

Go-ahead for first Genoa-Milan high-speed tunnel

The Italian Interministerial Committee for Economic Planning (CIPE) has approved starting construction of Lot 1 of the dei Giovi tunnel for the Genoa-Milan high-speed rail scheme. Funding of EUR 720M had been agreed in May,

but the whole scheme has a total budget cost of up to EUR 6.2bn. The main function of the route is to improve transport of goods between Genoa and Rotterdam for northern Europe as a TEN-T priority route.

Maddalena design approved

CIPE has also approved the design of the Maddalena exploratory tunnel, which is part of the proposed Turin-Lyon high-speed railway route. An

environmental impact assessment was also approved at the end of October. During a review of TEN-T infrastructure projects by the European Commission, this route suffered a EUR 9.18M cut in funding. These most recent approvals appear to be aimed at one of three EC conditions to avoid further cuts. Others are a new agreement to be signed before Christmas, and a clear mandate to the Lyon Turin Railway (Ltf).

Whatever your challenges are

In the construction of new space underground, MEYCO® provides more than purely equipment and chemicals for sprayed concrete. Its new solutions range from the field of TBMs and injection to waterproofing and fire protection, all supported by the expert engineering knowledge of our global team.

www.meyco.basf.com

 **BASF**

The Chemical Company



Expanding Horizons

Underground

MEYCO

Mosen fan signed up

GERMANY

Systemair of Boxberg-Windischbuch has signed an exclusive licensing agreement with Mosen for the Mojet jet fan system for tunnel ventilation.

The licence covers production and marketing of the fan design developed by Dr Fathi Tarada, managing director of Mosen. The main objectives of the technical development are to reduce the space requirement for fans, to increase energy efficiency and to reduce the number of fan units required in each tunnel. (See Ventilation Technical Review p29).

Kurt Maurer (L in photo), managing director of Systemair, commented "This licence agreement represents a further step for Systemair into the future,

since it will enable us to win additional market share in the area of tunnel ventilation and to differentiate its products from those offered by the competition."



Gorman and Liebherr inducted into AEM Hall of Fame

USA

The Association of Equipment Manufacturers (AEM) announced the induction of Jim Gorman, of Gorman-Rupp, and Hans Liebherr, of Liebherr, into its Hall of Fame.

"We are pleased to recognise these individuals whose vision and leadership have contributed greatly to the growth and strength of our industry," said Dennis Slater, AEM president.

Liebherr developed and

patented the TK 10 tower crane in 1949, which became the platform for his crane business, expanding into a variety of other construction equipment and industrial products.

"He was an early pioneer of high-pressure hydraulics, which still set the highest industry standard in excavators," AEM commented. "Dr. Liebherr fostered a corporate culture in which innovation and an entrepreneurial spirit propel company progress."

Gorman's father started Gorman-Rupp and by 15, he was

on the road promoting the company, which became the first American manufacturer to offer a wide line of submersible pumps to meet the conditions of mining environments.

"His foresight to invest early in CAD/CAM design software helped his company lead the industry in construction pumps and water pollution control equipment," AEM commented. He is also credited with creating the first commercially available self-priming solids-handling trash pump.

Hochtief's hydropower contract

PERU

Hochtief Construction won a EUR 110M (USD 144M) contract to build the Cheves hydroelectric power station in Peru, including 17km of tunnel.

The run-of-river 168 MW hydroelectric power generation plant, along the Churin and Checra rivers, will be approximately 245km north of Lima. With its location in the

Andes, the station is to be built 2000m above sea level.

Norwegian SN Power, which owns 99 per cent of the plant's developer, Cheves, announced in September it would invest USD 400M in the project. The plant is to be operational, covering the peak electricity requirement in the Lima region, from the end of 2013.

This is the second hydroelectric power plant construction for Hochtief in South America with the

first phase of the La Confluencia facility in Chile to be handed over at year-end.

At the same time, Hochtief announced the award of two infrastructure bids in Australia for its subsidiary, Leighton: an EUR 166M (USD 217.5M) share of a EUR 578M (USD 757M) contract for 5km of new highway that went to John Holland, and an unknown share of a EUR 210M (USD 275M) rail link with Thiess.

News in brief

■ Marmaray Project gets extra funds from Japan

The Japanese government has approved an additional loan for the Marmaray Project, which is constructing an undersea rail tunnel in Istanbul to connect both sides of the city. The 2005 loan has been increased from JPY 98.7M (USD 1.18M) to JPY 140.8bn (USD 1.6M).

■ Femern recommends immersed tunnel option

The Danish government-appointed planning body, Femern, said it favours an immersed tunnel for a fixed link between Denmark and Germany across the Fehmarnbelt because it would entail fewer risks, in both the construction and operational phases, than a cable-stayed bridge. The 30 November announcement followed the publication of two project proposals earlier in the month, with calculations showing an 18.1-km immersed tunnel would cost DKK 37.9bn (USD 6.95bn) and a cable-stayed bridge DKK 38.5bn (USD 7bn). Both estimates reflect 2008 prices. A decision is expected in early in January 2011.

■ Atkins acquires Gimsing & Madsen consultancy

Atkins has acquired Danish bridge and structural design consultancy Gimsing & Madsen for GBP 2.8M (USD 4.5M). Atkins looks to boost its capability in bridge and tunnelling design and compete in the Scandinavian road and rail sector.

■ Lawyers merge

Kilpatrick Stockton, an international law firm, headquartered in Atlanta, USA, specialising in construction, infrastructure and employment matters, is merging with Townsend and Townsend and Crew, intellectual property specialist of San Francisco. The merger is effective 1 January.

Orica records profits growth

AUSTRALIA

Full year net profits after tax to 30 September for the Australian-owned Orica group rose to AUD 1319M (USD 1266M) from AUD 777M (USD 746M). Major activities in the tunnelling market are explosives from Orica Mining Services and Minova's construction and ground control chemicals, rock bolts, drilling equipment and materials for ventilation and water control.

During the year, completed acquisition of parts of Dyno Nobel's commercial explosives business, and demerged the Dulux Group.

Record net profit after tax before individually material items of AUD 676M (USD 648M) was achieved. This is Orica's ninth consecutive year of profit growth and is ranked as one of the top 30 companies on the Australian stock

exchange according to market capitalisation.

Orica's managing director and CEO, Graeme Liebelt said the record result demonstrated the resilience of the company's strategy and the benefit of continued focus on business fundamentals. The results have been achieved in the context of global economic challenges and the adverse impact on translated earnings of a strengthening Australian dollar.

The Minova business delivered an increase in EBIT (earnings before interest and taxes) of 2 per cent to AUD 147m (USD 141M) in difficult trading conditions. The improvement is attributed to better margins in the US steel rockbolts business and greater penetration of the Chinese markets. Minova has also experienced a steady recovery in demand in Russia, the Czech Republic and South Africa, but



Above: CEO Graeme Liebelt said the record shows resilience

conditions are still soft in Western Europe, Poland and the US.

Mining Services (including explosives) achieved a record EBIT up 4 per cent to AUD 768M (USD 736M) despite poor demand in Europe and adverse weather in Australia and Indonesia affecting mining operations. There was strong growth of 32 per cent in electronic blasting systems.

Bucharest takes metro M5 bids

ROMANIA

Six JV/consortia have been preselected to construct the 9km-long metro M5 line from Hasdeu station in the city centre to Drumul Taberi in the western suburbs, and four have submitted final bids. The bidding contractors are Greek Aktor, a JV of Astaldi, FCC, Delta ACM and AB Construct, Strabag-Straco, and a JV of Dogus, Gulermak and Moscovskii Metrostroi.

Local business media report that the lowest bidder is Astaldi-FCC-Delta ACM-AB Construct at EUR 214M (USD 279M), and the highest is Strabag-Straco at EUR 453M (USD 590M). The other two preselected contractors, not submitting bids, were Max Bogl and Porr Technobau. The contract will be awarded to the selected contractor early next year.

The state-owned metro management company, Metrorex, has scheduled the construction

contract, including stations, for about 2.5 years, with a further five years for furnishing and commissioning to operation. Financing is being aided by a EUR 395M (USD 514M) loan from the European Investment Bank with EUR 800M (USD 1042M) from government budgets.

In October Metrorex announced that it would choose a consultant in the Spring for a

new line to Otopeni and Henri Coanda Airport to the North of the City. One outstanding decision is whether the line will connect from the existing 1 Mai or Piata Victoriei metro stations in 'downtown' Bucharest. The line will be financed with a EUR 315M (USD 410M) grant from the Japanese government. The whole project is valued at EUR 1.2 billion (USD 1.56 billion).



The new M5 line will expand the existing metro network

People news

Ross Dimmock has joined TAM International as regional director – Europe & Middle East and as tunnelling and mining director – UK. He was previously technical director of the Tunnel Division at Mott MacDonald and was previously with MBT/BASF Construction Chemicals as technical director of the Underground Division.

Andreas Enzier will be joining Normet in Switzerland on New Year's Day as vice-president business development and marketing. He has 12 years on construction chemicals experience, mainly of concrete admixtures, having had several senior international positions with MBT, Degussa and BASF; most recently as regional marketing director for BASF Flooring Europe.

In North America, Steve Archer becomes general manager of Normet Canada, based in Sudbury. He joins from Atlas Copco where he was most recently product line manager – Canada for rock drilling tools.

Morgan Sindall has appointed Natasha Cottell as business development coordinator for the Thames Valley, to be based in Theale. She will be responsible for producing pre-qualification questionnaires and tender documents, as well as assisting the business development team.

Dywidag-Systems International (DSI) has appointed Hans Wlodkowski as regional CEO for the Europe-Middle East-Africa (EMEA) marketing region. He is responsible for delivery there in the key markets of mining & tunnelling, geotechnics, concrete accessories and post-tensioning. Wlodkowski has particular experience in special construction and post-tensioning combined with threadbar technology.

Largest Austrian contractor lands largest Austrian contract



KORALM TUNNEL

The largest construction contract in Austrian history has been awarded to a JV under the technical and commercial leadership of Austria-based construction group, Strabag (T&T November, page 9).

The contract, which was signed on 28 October, was valued at EUR 570M (USD 759M). The client, Österreichische Bundesbahnen (ÖBB), the Austrian federal railway authority, required the construction of the Koralm tunnel, which, when completed, will become the longest rail tunnel in Austria and among the longest in the world. The longest rail tunnel currently in use is the Seikan Tunnel in Japan at 53.9km.

The 32.8km Koralm tunnel is part of the envisaged 130km 'Koralmbahn' rail link between Graz and Klagenfurt in the southern Austrian regions of Styria and Carinthia. When completed it will make up a major section of the

Baltic-Adriatic axis of Trans European Network (TEN) Corridor No. 23, linking Gdansk, Warsaw, Vienna and Bologna.

Strabag and the other member of the consortium, fellow Austrian company Jäger Bau, will undertake the work jointly as an integrated JV. Strabag takes the sponsorship. Work will begin early in 2011 with completion anticipated by late 2018.

The main section of the tunnel will run for 20km of the total 32.8km. Two parallel, single-track bores will be constructed with the New Austrian Tunnelling Method (NATM) for the first 2.5km. The remainder will be excavated by two mixed-shield TBMs of 9.9m diameter, as per the requirements set out during tender. The TBM supplier has yet to be decided. The Koralm tunnel will pass under the Koralpe mountain range, also called Koralm, which has a maximum peak of 2,140m in the form of Grosse Speikkogel Mountain.

Above: Wayss & Freytag and Granit bore Koralm Tunnel section 1

Approaching the site has presented an interesting technical challenge. The only access shaft is located near Deutschlandsberg at a point on the tunnel alignment some 3km from the eastern portal and centred between the two tubes. The maximum overburden is approximately 1,000m.

Strabag admitted that it experienced very tough competition for this contract due to the global recession, stating its assessment that the tunnelling market of Central Europe is especially low at this time. It won the contract with the lowest bid. "We are currently finishing work on the Gotthard Base Tunnel in Switzerland. It is wonderful that we now have the opportunity to again deploy our decades of expertise in tunnelling in our home country of Austria," said Hans Peter Haselsteiner, CEO of Strabag.

This particular contract applies only to the main portion of the

tunnel. Strabag was not involved in the excavation of the other two sections at the time of writing. The first is already under construction while the second tender has not yet been released.

Strabag will also only be dealing with the excavation and construction aspects of the tunnel itself. Handling of rail works, electrical installation and so forth will be decided with the issue of a separate tender.

Strabag is one of Europe's leading construction groups. With some 75,500 employees, Strabag generated a construction output volume of EUR 13bn (USD 17bn) in the 2009 financial year. The company expects a slight decrease in its output volume in 2010 from EUR 13bn to EUR 12.9bn. Output is expected to grow by 5 per cent to EUR 13.5bn in 2011 and by 1.5 per cent to EUR 13.7bn in 2012.

Alex Conacher

NFM TECHNOLOGIES. TUNNEL BORING MACHINE MANUFACTURER.

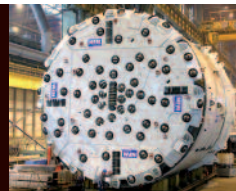


OUR MECHANICAL EXPERTISE WORKING FOR YOUR PROJECTS

NFM Technologies is a manufacturer of tunnel boring machines from 4 m to over 15 m in diameter, for any type of geology, making large-scale projects possible for rail, road or water infrastructures.

NFM Technologies' broad range of competences as an OEM in the cutting-edge mechanical sector means that it can propose innovative technical solutions, integrating specific requirements for each project and guaranteeing a high level of equipment reliability.

Whether for improving access to regions, developing infrastructures, or improving quality of life, our expertise is available to meet with your needs.



Hard-rock TBM



Soft ground TBM



Dual mode TBM



NHI GROUP

Creator of underground spaces

TUNNELS AND GALLERIES: Rail | Road | Water

www.nfm-technologies.com



Subcontinent weathers the storms

The combination of crowded cities boasting impossibly over-capacity roads with an increasingly energy-thirsty nation has resulted in a number of government-led tunnelling projects made possible by readily available state funding and foreign development loans, Alex Conacher reports

The tunnelling industry in India has given no indication of collapse, despite the recession. Speaking in 2009, Ruben Patel, managing director of Patel Engineering, a significant contractor in microtunnelling and many other sectors, pointed to government projects as the reason for his company's ability to prosper in the economic downturn. He added, "In a worst case scenario, these projects may get delayed to a certain extent. By contrast, private sector projects are severely affected due to the liquidity crisis."

A focus on metro...

If government expenditure is key for the survival of the tunnelling industry in a market hit by recession, the Indian Government is certainly not shirking from the task. Combining state and national funds with foreign investment—particularly from the merged Japan International Cooperation Agency (JICA) and Japan Bank for International Cooperation (JBIC)—a lucrative funding packet is available for many key infrastructure projects. The continued heavy investment in metro rail transport systems in particular is a clear statement of Indian intent. The industry will be buoyed and the roads shall be relieved, delivering economic benefits on several fronts.

To write that metro projects are thriving in India at the moment would be a

Right: Launching the 10m diameter Robbins double-shield TBM for the 19.2km long Pula Subbaiah Veligonda Tunnel No. 2 in a water supply scheme. It features Robbins' longest single-flight belt conveyor; **Below:** A busy street scene from Chennai shows the need for a metro



monumental understatement. Included in a list of 19 cities approved for a rapid mass transit project under the Jawaharlal Nehru National Urban Renewal Mission are: Delhi, Calcutta, Mumbai, Chennai, Ahmedabad, Hyderabad, Lucknow and Bangalore with many more proposed.

Although a detailed description of all of the projects would be impossible, the work on the Delhi Metro deserves a special mention, as it is the largest of the infrastructure projects (see page 19 for Delhi feature). The recent phase two has been funded by a long-term soft loan from JBIC. With the total of all phases valued at around an estimated USD 10.3bn and the project spanning a quarter of a century, the network will consist of an impressive 413km total length of metro line built across the four phases. Completion is expected by 2021.

... especially Chennai

The Chennai Metro is a good case in point of government resources working with foreign funding in the public interest, as a public private project. Valued at

approximately INR 14,000 crores (USD 3.1bn), 41 per cent of the cost will be met directly by the Government of India and the state Government of Tamil Nadu on a 50-50 equity basis. The remainder will be funded by a loan granted by JICA, broken down into a 0.01 per cent interest rate for consultancy services and a rate of 1.4 per cent for construction and procurement services. The loan will be repaid over 30 years with a moratorium period of 10 years. The loan was signed by the governments of India and Japan in Tokyo on 21 November 2008, despite the Chennai Metro project not being finally approved by the Government of India until early the following year, on 28 January 2009.

Excavation of the running tunnels will be undertaken by 'latest TBMs', with the stations being excavated by cut and cover. This is a problem for traffic on the arterial roads of Chennai where the stations will be located as the process could take around two years to complete. Great importance is placed on this; a retired local police officer will be employed to liaise with the City Police





Headquarters on traffic management issues.

The tunnel will run 14.3km in corridor one with the remaining distance elevated, and 9.7km in corridor two, with, again, the remaining distance covered by elevated track. The average depth will vary from 15 to 17m from rail level and the tunnel will have an internal diameter of 5.8m. The minimum surface to tunnel clearance of 9m means the TBM will not be at risk of clipping utility tunnels.

Tunnelling is scheduled to begin at the start of 2011 with cost anticipated to be around INR 300 crores (USD 66M) per kilometre of underground track and INR 100 crores (USD 22M) per kilometre of elevated track. A preference for the least obstructive option for the narrow roads is quite clear, despite the tripled costs.

"A single six-coach metro train will remove 16 buses or 300 cars or 600 two wheelers from the roads at peak hours. The metro is expected to remove 13 lakh (1.3M) passengers per day from the roads by 2026 in Chennai alone," said chief public relations officer for Chennai Metro, S Krishnamoorthy.

Construction of the first phase of the project should conclude in 2014 or 2015.

Hydroelectric politick

Hydroelectric power has traditionally been another area of interest for the Indian government. Early successful projects such as the Pykara Dam provide inspiration for more recent endeavours such as the USD 1.57bn power plant at Dhemaji, the USD 1.3bn Kalai plant on Lohir River and even across the border, with the USD 2.6bn, 1,200MW Kohala hydroelectricity plant in Pakistan.

Chief among these in terms of size, however, is the Subansiri Lower Hydro Electric Power Plant project on the river Subansiri, close to North Lakhimpur, that forms the border between the states of Arunachal Pradesh and Assam in north-east India.

The client is the state-owned National Hydro Power Corporation (NHPC) that describes the work as the largest such project ever undertaken in India.

Engineering, procurement and construction contracts were awarded in January 2004 and April 2005. Soma is the contractor constructing the dam and tunnels.

The plant features a dam rising 116m from the riverbed and was expected to cost INR 6,285.33 crores (USD 1.38bn) by the 2002 estimate and requires the construction of eight 9.5m diameter headrace tunnels of horseshoe shape with lengths ranging from 608 to 1,168m, eight 9.5m diameter surge tunnels of horseshoe shape with lengths



between 400m and 485m and eight horseshoe/circular pressure shafts with diameters varying between 7.0m and 9.5m, and lengths of 168-190m. There will also be a 205m long tailrace channel.

A K Biswajit Das, executive director of Soma, wrote in his paper 'Geotechnical Assessment of Diversion Tunnels of Lower Subansiri Hydrel Project, Assam' that the rock encountered was "medium-to-coarse grained Middle Siwalik Sandstone and the overall tunnelling condition was fair to good."

One challenge is that the nearest railhead to the local town is in Nagaon, approximately 262km away by road. Another problem is the heavy rain. An annual average rainfall of 4,600mm results in the shutting down of all works between May and September.

The project will create an estimated 2,000MW generating capacity when completed, split between eight Francis turbines, and is scheduled for completion by the end of 2012 in a memorandum of understanding made in November 2010; however controversy surrounds the project.

In 2009 a committee of eight people was set up to investigate the Subansiri project. Drawn from the Department of Transport among other organisations, it accused the project of 'gross inadequacy' of design. Environment chief of NHPC, Vipin Kumar responded saying, "there has been a lot of confusion and apprehension about the ecological toll but there is no scientific basis to that."

Jairam Ramesh, state Minister of Environment and Forests called for a halt to construction, accusing the government of



Above, left: The perilous route to Patnitop tunnel site; Above, right: Early groundworks in preparation for the Patnitop Tunnel

using Arunachal Pradesh as a 'pawn in the race with China.' Arunachal Pradesh is a region politically charged on the international level as it is also claimed by China as part of South Tibet.

Water supply is another important facet of the Indian tunnelling business whether inked to hydroelectric schemes or as standalone projects. Several are complex and involve tunnelling at record lengths through tough ground conditions.

Himalayan highways

Transport investment in India does not just concentrate on the accessibility of densely populated districts in an urban sprawl. The Patnitop (see *T&T Asia*, October 2010, p15) and Rohtang (see *T&T Asia*, October 2010, p10) mountain tunnels were designed to alleviate the use of the high, snaking mountain roads that are the traditional route over the Himalayas.

IL&FS Transportation Networks awarded the USD 570M contract for the Patnitop tunnel. This is a privately funded venture, however the National Highways Authority of India will award a semi-annual annuity for the infrastructure and services. The Border Roads Organisation, an inter-ministerial civil engineering group that works in conjunction with the Indian Army, awarded the Rohtang tunnel contract. These tunnels will hopefully show the merits of sequential excavation in the geologically dynamic Himalayas. ■



KILPATRICK
STOCKTON LLP

Attorneys at Law

Contract Negotiation • Dispute Avoidance and Resolution • Mediation • Arbitration • Litigation

DEEPLY RELEVANT

Kilpatrick Stockton cannot help you build a better tunnel —
but we can help you prove it.

Global Construction & Infrastructure Practice

Randall F. Hafer

rhafer@kilpatrickstockton.com

404 815 6289

www.kilpatrickstockton.com

ATLANTA AUGUSTA CHARLOTTE DUBAI NEW YORK OAKLAND RALEIGH STOCKHOLM WASHINGTON WINSTON-SALEM



Capital metro expansion



In a race against the clock, contractors on the Delhi Metro have had to go 'all guns blazing' to make the tight deadlines laid down by the client. Jon Young spoke with Pawan Bhasin of contracting joint venture ITD (Ital-Thai Development)-ITD Cementation about the experiences on contract BC 24

Construction of the London Underground began in 1860 and between then and now the network has grown to 270 stations and 402km of track, giving an average of 2.7km of track each year. The New York subway has averaged 2.4km of new track since construction began. By the end of Phase II in March next year the Delhi Metro will have averaged 14km of new track a year, five times faster than the London and New York systems and giving Delhi a world class metro inside 15 years.

Phase II, which is reaching completion, was sped on by the pressure of the Commonwealth Games held in the city this Autumn. The pressure of the games deadline was passed onto the contractor, making the planning and scheduling of works a crucial factor in meeting the demands of the contract.

Once Phase II is complete in March next year the Delhi Metro will consist of six lines including 31 underground stations. It has a combination of elevated, at-grade and underground lines and uses both broad

gauge and standard gauge rolling stock.

Contract BC 24

Delhi Metro Rail Corporation (DMRC) began construction of Phase II between 2006 and 2007 to extend its existing lines and take them to adjoining states of Haryana and Uttar Pradesh. The extensions were scheduled to be completed in four years.

"Our package called BC 24 was one of the last in series to be awarded as design and construction," says Pawan Bhasin of contracting joint venture ITD-ITD Cementation. The contract is made up of a twin-bore tunnel of 4.2km driven by TBM from Khan Market to Nehru stadium and on to Jangpura station, and an intervention shaft (IVS). It goes into cut-and-cover from Udyog Bhawan to Lajpat Nagar for underground works on Central Secretariat-Badarpur corridor of Delhi MRTS. The time period allocated was just 35.5 months.

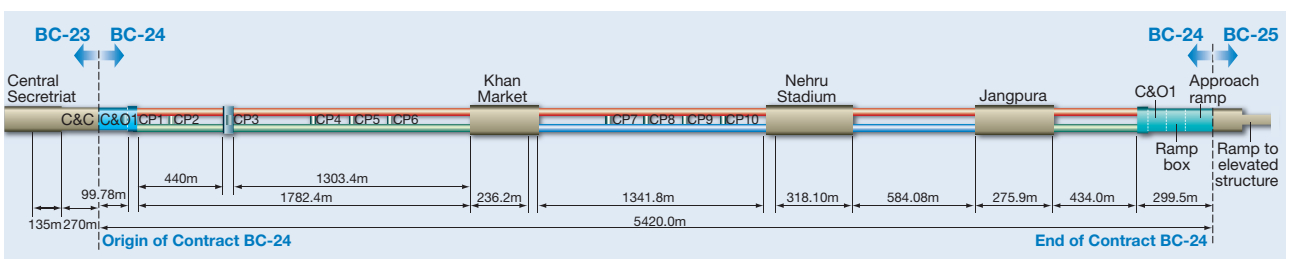
BC 24 runs from Central Secretariat-Udyog Bhawan starting in a short cut and cover section heading south and quickly

becoming twin-bored TBM tunnel for 1.8km to Khan Market station. The stretch to Khan Market station was excavated using TBMs numbers three and four. Heading north for Khan Market were TBMs numbers one and two on a 2.3km drive from Jangpura station and passing through Nehru Station *en route*. The southern most end of the contract between Jangpura Station and the elevated track of contract BC 25, a stretch of less than 1km, was driven by TBM numbers three and four after they had completed the northern tunnels. The stations and cross passages were excavated using the New Austrian Tunnelling Method (NATM).

The alignment is an extension of the existing Line II and designed to link the southern part of Delhi and to ultimately connect with the neighbouring industrial town of Faridabad, part of the NCR in Haryana state. The planners also took account of the main games Jwaharlal Nehru (JLN) Stadium and existing business centres of South Delhi namely Nehru Place and Jasola.

The alignment was kept underground until Lajpat Nagar largely due to aesthetic

Below: Project overview. Blue: TBM 1; Red: TBM 2; Pink: TBM 3; Green: TBM 4





Left: Breakthrough of one of the 6.64m diameter EPBM

consideration—protecting the beautiful Lutyens Delhi. “Needless to say, initially up market South Delhi residents also protested and asked for an underground metro as they felt it will infringe upon their privacy,” says Bhasin.

Cutting under Delhi

Generally the geology of Delhi consists of clayey, silty sand with high permeability characteristics but the launching point for TBMs three and four heading south from Udyog Bhawan was found to have quartzite rock at a shallow depth. The

contractor carried out site investigations that revealed the rock dipped sharply in the southerly and easterly directions.

“BC 24 alignment took off from Udyog Bhawan (Offices of Ministry of Industry) and we were to provide a shaft at chainage 0 to lower the TBM. However, detailed soil investigation showed rock strata (quartzite) at the depth of 4m resulting in shifting ahead of shaft by 200m along the alignment. So the first 200m of tunnel was constructed by cut and cover method,” explains Bhasin.

Four TBMs were deployed on the

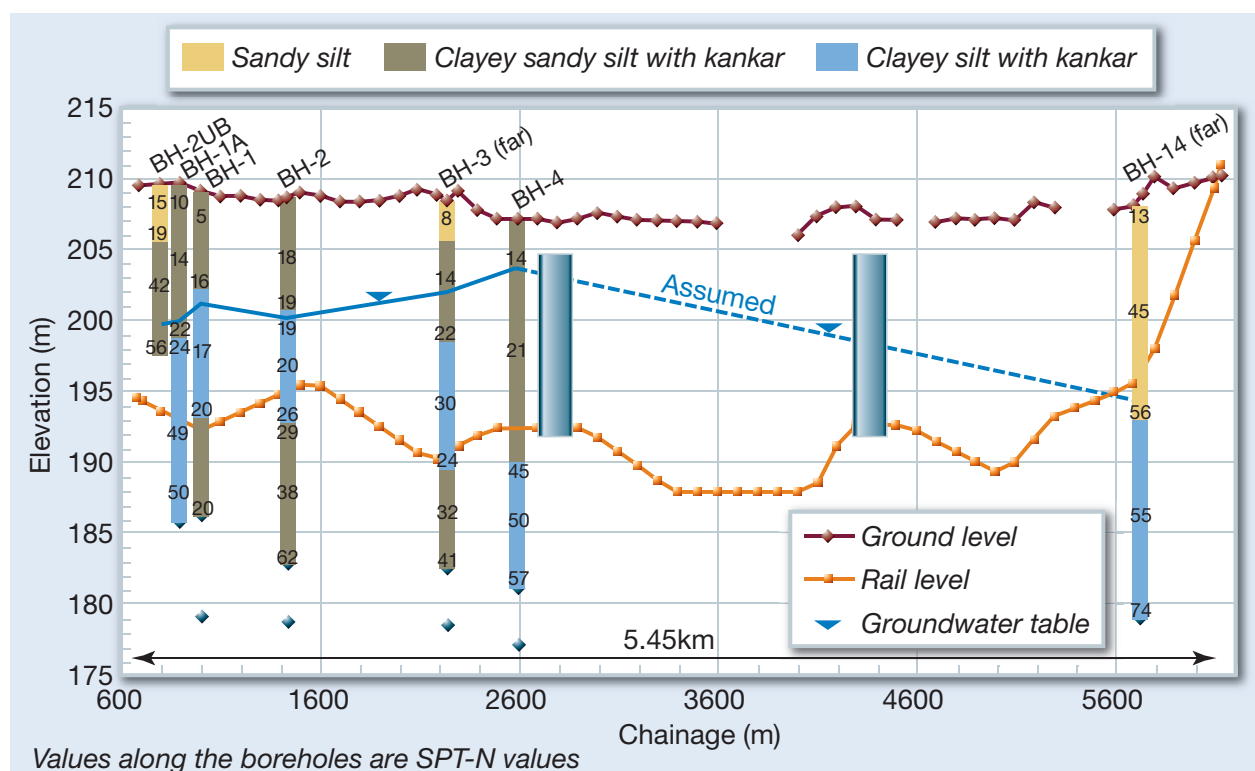
project. The contractor opted for Herrenknecht EPBMs as it believed they were the best choice for soft, silty, highly saturated soil conditions. “NATM or other tunnelling methods like drill and blast were not possible in these conditions and also part of the alignment passed under residential buildings, therefore TBM tunnelling was quite a safe and fast methodology,” says Bhasin.

Project client Delhi Metro Rail Corporation wanted a finished tunnel diameter of 5.8m so the contractor ordered TBMs with a 6.64m diameter cutterhead. The TBMs had a design thrust of 22 750kN, a main bearing diameter of 2.6m, main bearing power of 630kW, torque of 5,213kNm and a maximum advancement of 80mm/min. With five back-up gantries behind, the total length of complete assembly was 76m each.

Workshop testing and commissioning of all four TBMs was done at Guangzhou, China. They were shipped to Mumbai in July 2008, and arrived on the Delhi job site by road in September 2008—less than a year after the award of the contract.

“We have used precast segments for permanent lining. Each ring consists of six different segments. The rings are of two

Below: Site investigation boreholes along the tunnel alignment with surface and groundwater levels





Right: The 1.5m by 1.2m segments form the tunnel lining in a 5:1 arrangement

types, 1.5m length and 1.2m length. The outer diameter of each ring is 6.35m and inner diameter is 5.8m. The design strength of the concrete segments is M45," says Bhasin.

Khan Market Station

In the centre of the contract lies Khan Market Station. It is the meeting point for the two TBMs heading north with the two TBMs heading south. Above ground the site is congested with busy streets and extensive buildings. Below ground the contractor had to navigate through building foundations and complex utility networks.

The area from Khan Market to Jangpura Station is an upmarket district in Delhi, which meant the contractor had to be particularly careful in minimising disturbance while tackling the challenges. Logistically the site was very complicated. The congested area and the pressure to minimise disturbances meant managing traffic flows in the area was a priority for the contractor. The difficulty was compounded by night-time restrictions.

Many residents went further to protect their privacy by preventing surveys from being carried out on their buildings to monitor the effects of the tunnelling activity. With many of the high-rise buildings unable to provide structural drawings, the contractor was forced to take extra precautions to ensure the work did not result in damage to the properties above. At Jangpura the contractor was faced with boring tunnels beneath multi-storied residential apartments resting on individual spread footings and with no structural details available.

In these areas the contractor used pre-grouting with bentonite and polymer grouts to stabilise the ground ahead of the TBMs. In some areas, such as the 5-star Hotel Ambassador at Khan Market, additional piles were driven.

Passing along both sides of Khan Market station, and in parts passing within the station, were two brick arch sewers dating from British ownership. The 7m and 5m-diameter sewers needed to be relocated in order for the station to be constructed. Torrential rain in 2008 caused one sewer to overflow resulting in complete submergence of Khan Market Station and the entire tunnel between Khan Market and Nehru Station including the TBM. This one day of rain put the project behind by more than a month.

Managing the water table was to be a



long-term challenge for the tunnel. During TBM drives primary grouting was done. After completion of TBM drives generally secondary, including PU at some places, was done to prevent leakages. "During post-grouting we have used PU, silica gel, cement and microsilica," reported Bhasin.

Meeting the deadline

The main driver for constructing phase II of the metro was to provide a very good transport system for spectators of the Commonwealth Games." So we had to be fast to finish our project well before the start of the games," says Bhasin. The tight time schedule created several challenges.

According to the schedule the shafts and launch chambers needed to be ready prior to the arrival of the TBMs to site. This gave the contractor less than a year to complete the works. The challenge was complicated by the hard rock found on the northern launch site that led to further site investigations. But the shafts were successfully completed in time.

The mapping of utilities needed to be completed before tunnelling could start and the diversion of many was also a major

draw on time. This included the timely relocation of large diameter trunk sewers, water lines and other utilities along alignment, especially at station locations

As the contract was design and construct, the contractor and client had to develop a faster system for proofing and approving designs so that the work could fit inside the schedule. "The proactive approach of DMRC, their continuous monitoring and support, quick decision making of their consultants, and having the extensive experience and zeal of the site team could overcome all challenges of this difficult project," says Bhasin.

When up and running, each TBM was to average an advance of 350m per month with a peak month of 450m of tunnel, despite the challenges the project faced. In the station excavations the diggers were able to remove 250m³ of soil a day or 100m³ of rock.

"The entire project was successfully completed by us and handed over to customer two months before contractual time period of 35.5 months. The line was made operational for public on 2 October 2010, the day of the opening of commonwealth games," says Bhasin. ▀

The Delhi Metro

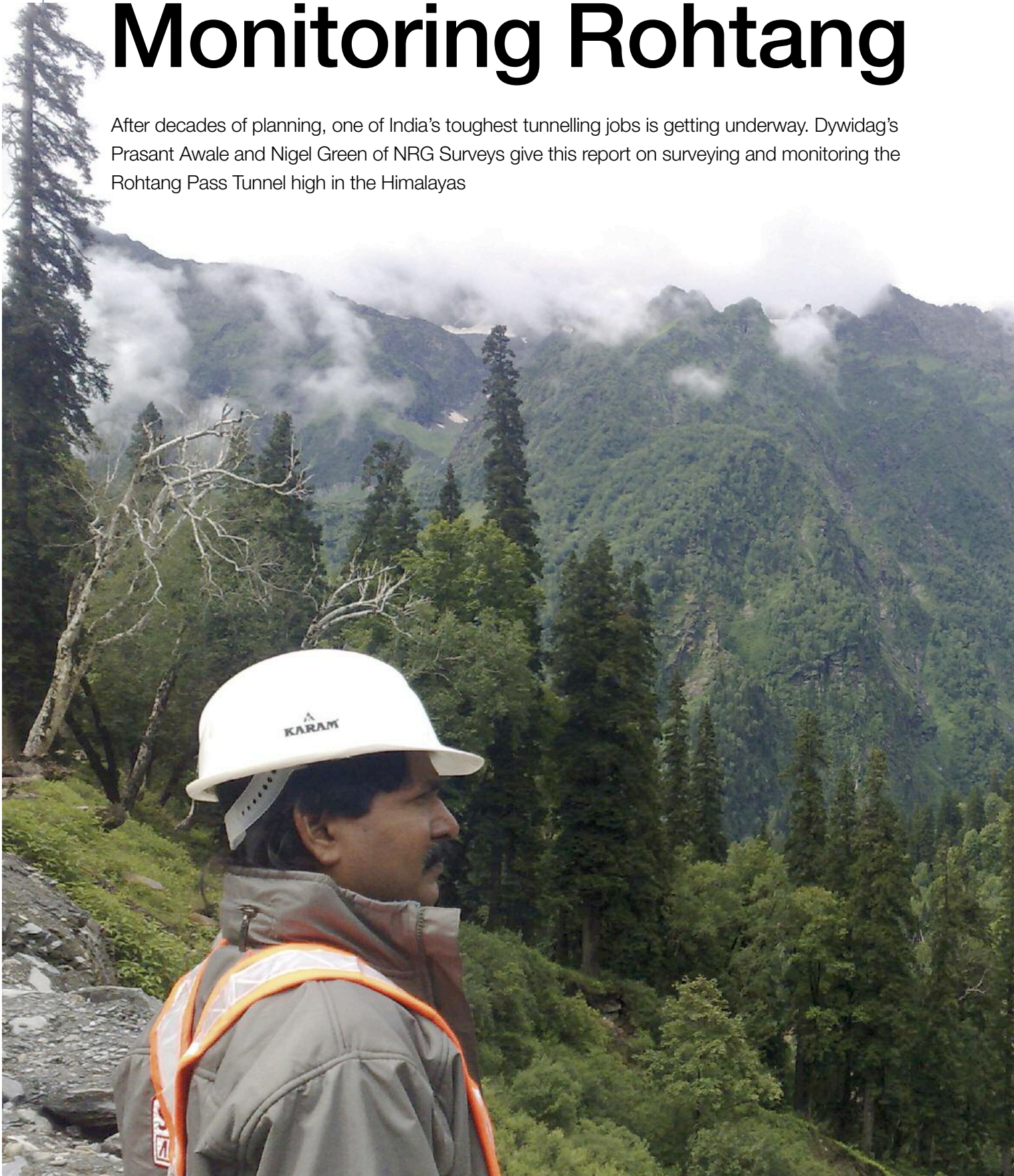
Planning for the metro started in 1984, when the Delhi Development Authority and the Urban Arts Commission came up with a proposal for developing a multi-modal transport system for the city. The Government of India and the Government of Delhi jointly set up the Delhi Metro Rail Corporation (DMRC) in 1995. Construction started in 1998, and the first section, on the Red Line, opened in 2002, followed by the Yellow Line in 2004, the Blue Line in 2005, its branch line in 2009, and the Green and Violet Lines in 2010. Subsequently, these lines have been extended and a string of new lines are opening in Phase II of the project, including the Delhi Airport Metro Express whose opening has been postponed due to safety concerns (see *T&T* Nov., p9).

As cities grow in size, the number of vehicular trips on road systems goes up. The city of Delhi with a population of 16.2 million should have a mass rapid transit system (MRTS) network of at least 200km, whereas actually it was 65km at the end of phase I. Today the traffic on roads of Delhi is a mix of cycles, scooters, bikes, cars, buses, and auto rickshaws jostling with each other. "To rectify this situation it is very necessary to develop and extend the metro rail in Delhi, which is environment friendly being operated electrically and economic and convenient for the common people," says Pawan Bhasin of contracting joint venture ITD-ITD Cementation.



Monitoring Rohtang

After decades of planning, one of India's toughest tunnelling jobs is getting underway. Dywidag's Prasant Awale and Nigel Green of NRG Surveys give this report on surveying and monitoring the Rohtang Pass Tunnel high in the Himalayas





Work on the Rohtang Pass Tunnel project has finally started, decades after it was initially conceived in 1983.

Located at an altitude of more than 4000m in the Pir Panjal range, 51km from Manali, Rohtang Pass remains snowbound in winters for nearly six months, cutting off the tribal Lahaul-Spiti Valley in Himachal as well as the strategically vital Ladakh region of Jammu and Kashmir.

It will be the longest tunnel in the world at an altitude of more than 2500m. The nearest in comparison to Rohtang Tunnel is the Anzob road tunnel in Tajikistan (5km long at 3,100m), Khojak rail tunnel, built in 1891, near Quetta, in Pakistan (3.9km at 3600m) and Eisenhower Memorial Tunnel in the US (2.7km, at 3,100m).

Special challenges of this prestigious project are the altitude, and the extreme climate as well as the geological conditions in the Himalayas. Within the tunnel area rock comprises mainly schists and migmatite with disturbed zones expected and in some individual areas highly squeezing rock. Given these rock conditions, NATM provides many advantages. NATM enables flexible adjustments of the excavation works as well as the support systems. Moreover, the equipment for the drill-and-blast excavation of the NATM can also be transported on the small and twisty pass road to the entrance of the tunnel. The existing road with its many switchbacks would present extreme difficulties when transporting a TBM.

It is the most challenging task that the Border Roads Organisation (BRO) will have undertaken in its 50 years of existence and it has contracted Austrian firm Strabag as the leader of a joint venture with Indian construction company Afcons.

German Dywidag International, an affiliate of Strabag, is performing the tunnelling works.

The challenge of dimensional control is being met by Dywidag's surveyors whose first job was to connect the two ends of the tunnel by traversing and spirit levelling a route of 180km threading its way over the mountain pass. GPS observations were also carried out and after a campaign lasting 70 days involving up to two teams of surveyors and their assistants they are now confident that the tunnelling works carried out from both ends will meet somewhere in the middle to within a few centimetres.

Apart from the obvious task of ensuring accuracy in the alignment the surveyors are responsible for recording movement and compression of the rock as the heading proceeds. This is essential for the



Harendra Prasad, Dywidag's chief surveyor



Below, top: Project surveyor Prasant Awale

Below, bottom: Deformation graphs

geotechnical engineers to assess the elasticity of the surrounding rock to design appropriate support systems and to ensure the safety of the miners in the tunnel.

Deformation monitoring

To monitor the movement, targets are being installed into the roof and walls of the tunnel every 15m along its length and their spatial position recorded at least twice a day. Determining the position of each target to within the necessary 1mm tolerance in the confined and hostile environment underground presents its own challenges, especially as the area they are working in may also be moving. This involves observing a network of control points continually along the length of the tunnel linking it to rigorously observed stable points on the surface.

Timely analysis of the data is required and a high level of confidence in the results is essential prior to passing to the geotechnical engineers as these will determine whether additional costly supports are needed or whether the tunnel is in imminent danger of collapsing and the equipment and personnel evacuated from the excavation.

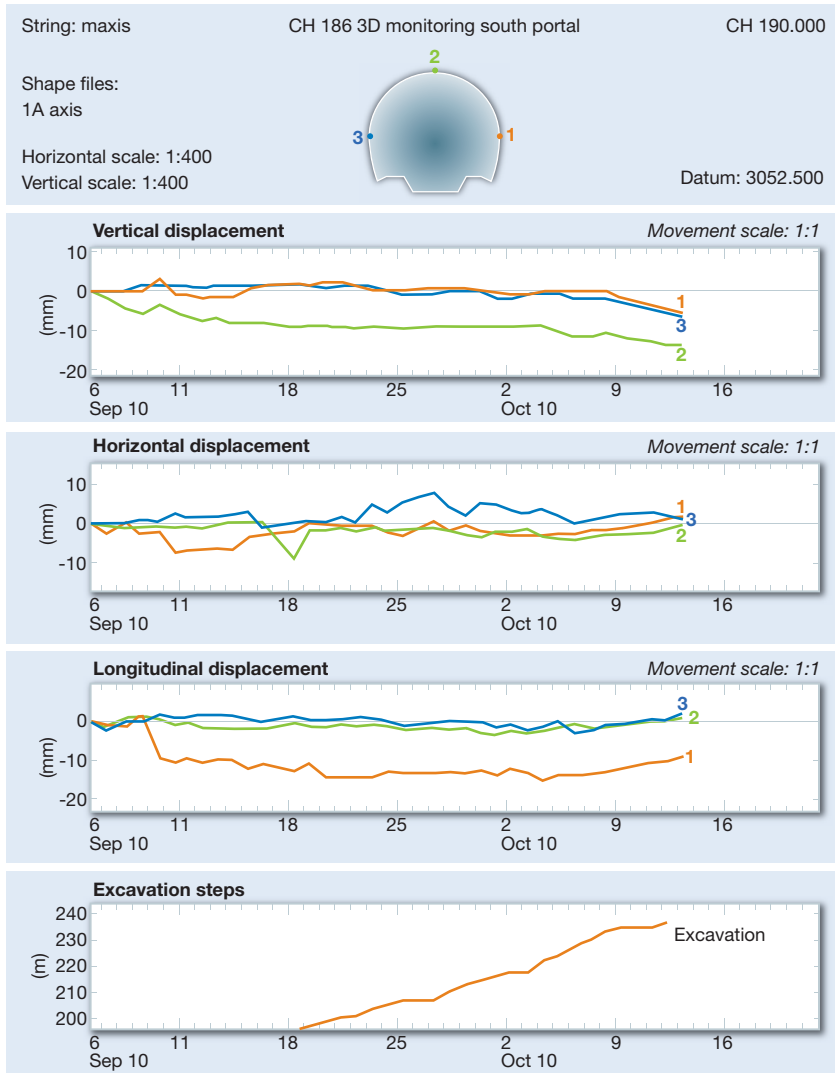
Software by UK Software Company NRG Surveys was chosen for the processing and analysis of the data, mostly due to their track record in tunnelling and the ease of use and flexibility of their system.

Observations are taken to reference stations and monitoring points using a Leica 1200 total station and the software firstly computes a precise position for the observing station by computing a resection to the multiple stable points.

Observed points are then loaded into the monitoring database, which connects them to previously observed positions. The software displays each group of points in relation to the proposed tunnel and presents a series of graphs, from which it can be seen how the movement is trending.

It is expected that the tunnel will compress and the rate of compression, i.e. the gradient of the graphs will slow down over a period of time. It is the speed of this slowing and its relationship to the position of the heading that tells the engineers how elastic or plastic the rock is.

Relationship to the face heading will also give an indication of the type of rock immediately in front of the heading as it can be predicted from a type of 'bow wave' effect if there is likely to be a fault or bad ground further on.





If the compression accelerates over time, then the rock is determined to be neither elastic nor plastic and possibly in danger. In this case the excavation works would cease and pilot bores taken to establish the condition of the material.

Assessing the trend of the movement can give a good indication of the type of ground that lies ahead. A most useful indication of this is by plotting a longitudinal section along the length of the tunnel and showing movement in relation to the progress of the face.

The software records the position of the face as it proceeds and can then interpolate the movement for a consistent relationship to the face (see figure 1).

A graph can then be plotted showing movement in relation to the excavation heading. When viewed alongside a graph of excavation against time it offers the geotechnical engineer an indication of how the terrain may be ahead of the face.

It is absolutely essential therefore that the surveyors are able to consistently provide accurate and timely results. Good surveying equipment that can withstand the rigours of working underground are essential and for this Leica 1200s have been chosen along with a Leica system 1200 GPS system.

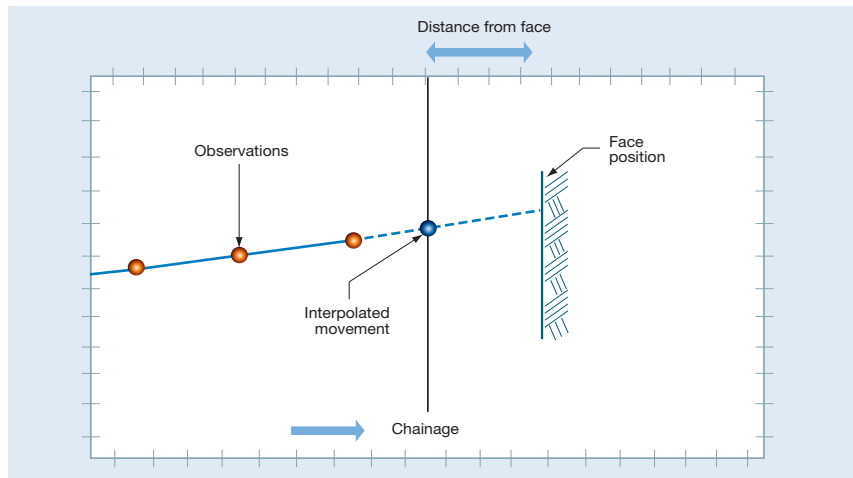
Good surveying practises are also essential. A particular feature of which is the need to observe a great deal of 'redundant' data, a term used by surveyors meaning that they will carry out observations several times in many different ways. Proper analysis of this data will then highlight errors. These fall into the categories of blunders, observations for various reasons that are rejected, systematic errors caused by loss of calibration of equipment and simple errors that are usually small in magnitude and relate to the precision of the equipment and the care taken in recording observations.

The use of a good software system that gives the surveyors the tools to differentiate between and deal with each of the types of errors and also to present the results in a clear fashion is paramount in order to meet the pressures of time involved with excavating 2km of tunnel each year for a period of five years. For this NRG Surveys tunnelling system was chosen.

Wiggles

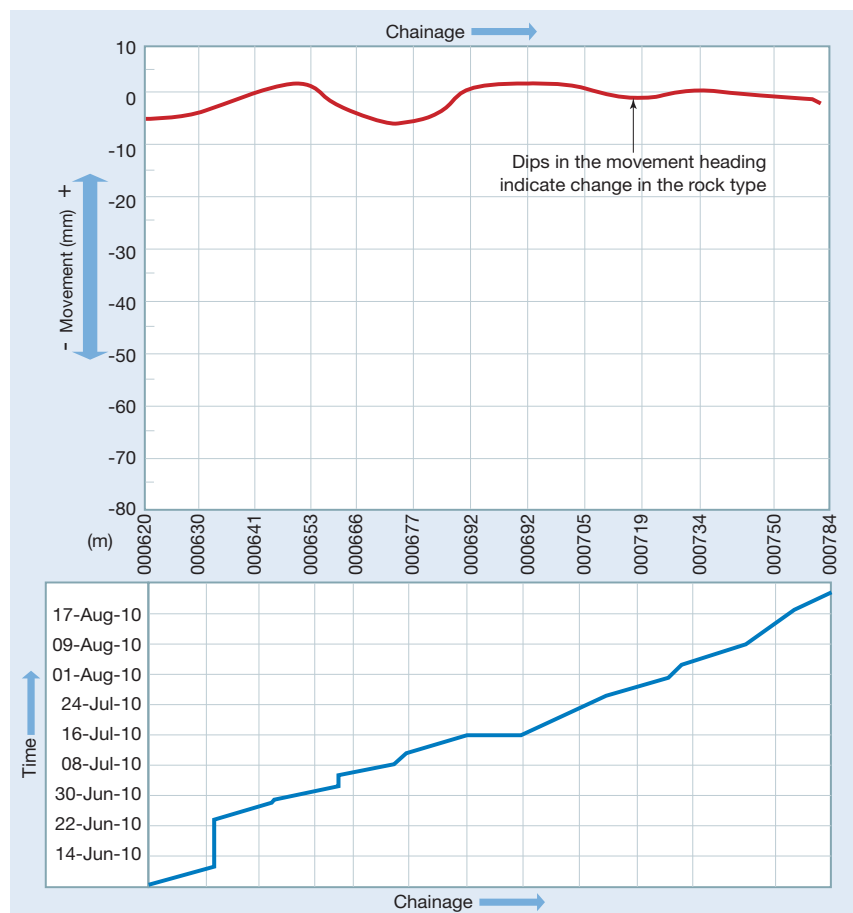
In order to maintain the correct alignment of the excavation, profiles are observed at 2m intervals along its length.

Observations are taken after excavation and prior to shotcreting, and then again once shotcrete has been applied.



Above: Figure 1, the software records the position of the face and interpolates the movement for a consistent relationship to the face

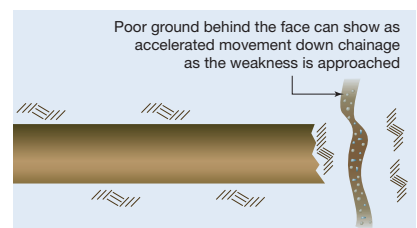
Below: Figure 2, a graph is then plotted showing movement in relation to excavation



Using these profiles it can be shown how much the excavation deviates from intended. Also quantities of excavated material and shotcrete may be calculated.

The tunnel consists of a shape or series of shapes following a geometric alignment.

How far each observed point differs from the proposed may easily be calculated but





Above: Monitoring the steel section; Below: Over and under break in the rock excavation

how far the tunnel as a whole is deviating is a little more subjective.

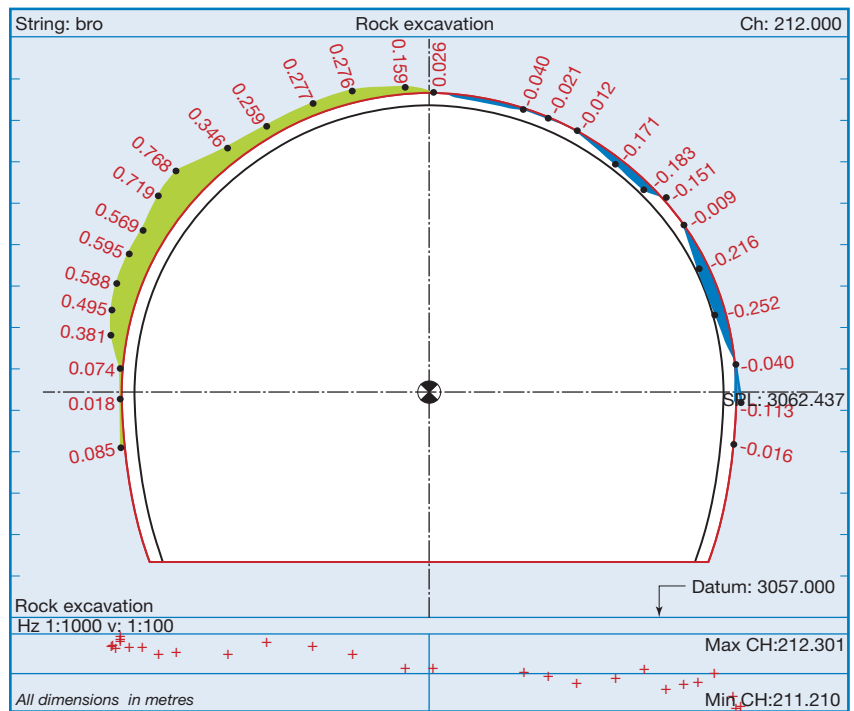
The software offers two solutions to this problem; the first is by taking each of the departures of the observed points in X & Y from the proposed shape and passing through a 'least squares' iteration to determine the best fit for the whole shape.

The second method assumes a circular profile and calculates the centre of a circle from each combination of three points. A 'best fit' centre is then calculated, again using a 'least squares' iteration.

Least squares is a popular solution for surveyors in determining the most probable solution to a group of observations. It requires that the squares of the residuals are a minimum and is used for a variety of functions, not least the adjustment of control networks. Where (S = the total sum that must be kept to a minimum covering points from 1 to n; i = the number of the survey point (i.e. 1, 2, 3, 4n) r = the value of the 'residual' at each survey point):

$$S = \sum_{i=1}^n r_i^2$$

The profiles are used on a daily basis to check the alignment of the excavation works but these may all be presented together in a graph to show the departures of the 'as built' alignment as a whole, often referred to as a 'wriggle'. From this graph it is possible to use the software's best fitting techniques to design a new geometric alignment through the 'as built' tunnel. ▀



Data	
Shape name	: O_Line 4
Shape file	: o_line 4+.shp
Observed points name	: as-built
Observed points file	: ch 211.sec
Best fit - Vertical alignment	: Held
Curve fitting	: Not applied
Best fit	: Circle

Results	
Min clearance	: -0.252
Max clearance	: 0.768
Circle fit centre X	: -0.494
Circle fit centre Y	: 0.095
Radius	: 7.334
Circle fit E	: 700730.315
Circle fit N	: 3582798.797
Circle fit L	: 3062.532
Min clearance after shift	: -0.258
Max clearance after shift	: 0.407
Overbreak	: 4.520
Underbreak	: 1.197

The bigger picture

For a overview of the Rohtang project see p10 of *T&T Asia*, October 2010.



GAUTRAIN SITE DEMOBILIZATION

Bombela Civils Joint Venture consortium (civil contractor to the Gautrain), consisting of Bouygues Civil Works, Murray & Roberts and the Strategic Partners Group (SPG) has reached the point of site demobilization. as a result the equipment / plant are available:



Refurbished PAUS Dumper 10000A 20t payload
interchangeable with Concrete mixer CIFA



Refurbished Shotcrete Robot PUTZMEISTER: Model PM 407



Refurbished Shotcrete Robot PUTZMEISTER: Model PM 500



Refurbished NORMET Himec 9915 B.A

LIEBHERR Tower Cranes 280 EC-H 12

For more information please contact:
Nilton Barreira (011 997 8414 / 078 804 3039)
nilton.barreira@bombelacjv.com



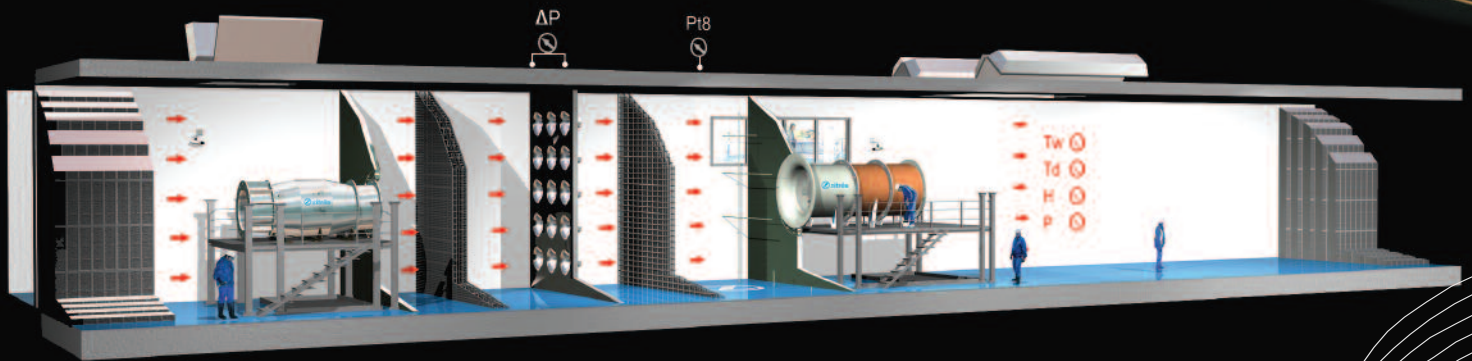
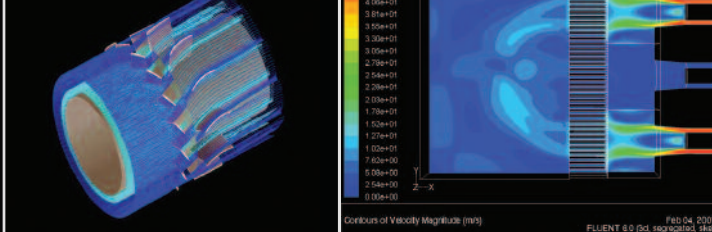
More than ventilation systems

The measure of our experience



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

ABSOLUTE VELOCITY LINES IN DIFFERENT SECTIONS



ZITRÓN, S.A.
Head Office: Autovía AS-II N° 2386
33392 Porceyo. Gijón. Spain
P.O. box: 404 - 33280 - Gijón. Spain
Telephone: +34 98 516 81 32
Fax: +34 98 516 80 47
E-Mail: zitron@zitron.com



Winds of change for tunnels environment

Improved standards of ventilation, the need for economy and provision for emergencies are all combining to create increased demands on tunnel ventilation design, plant and control. Maurice Jones reviews some of the latest developments

Tunnel ventilation has to perform several important and varying functions, and of course the combination of functions varies widely, depending on the application. There may be little in common between the performance requirements of road traffic tunnel, rail tunnel and underground metro stations due to operational factors such as the piston effect of traffic (usually trains), the risk of fire or collision emergencies and any significant natural ventilation effects due to location and climatic conditions.

These increasing demands on ventilation are not only affecting the design of new tunnels but also creating a major market in refurbishment. Combining the two are the tunnel fires of recent years that, if the authorities deem the traffic flow to be high enough, have necessitated the construction of a parallel, second, bore to separate traffic flows and create a safe refuge/escape route for tunnel users.

One such case is the Tauern Tunnel on the A10 route in Austria where, following the collision and fire of 1999, the national highway operator Asfina, decided to construct a second bore with improved operational systems that was opened in April this year. This allowed the original bore's systems to be upgraded, with a date next year for both to be fully operational. Civils refurbishment on the original bore has been carried out by Ostu-Stettin with Zitron Netherlands supplying and installing the ventilation equipment for a cross (traverse) flow system in both tubes.

The equipment supplied by Zitron included eight EB (extraction) fans with hydraulic vane control suitable for operation at up to 400 degrees C for 120 minutes, eight fresh air fans, 52 pressure jet fans for facilitating escape in an emergency and 18 louvre valves for ventilation control. As well

as installation, Zitron was also responsible for surveying the flow and pressure losses, test assemblies in the factory, leak tests, ventilation fire tests and volumes delivered, plus maintenance planning.

The wide range of axial and jet fans available from Howden Ventilatoren features corrosion protection and flameproof motors, with auto-variable pitch or variable speed drives, and potential for up to 100 per cent reverse flow. Tunnel fans supplied include those for the renewal and upgrade of the Mon Blanc Tunnel and the Gotthard Tunnel.

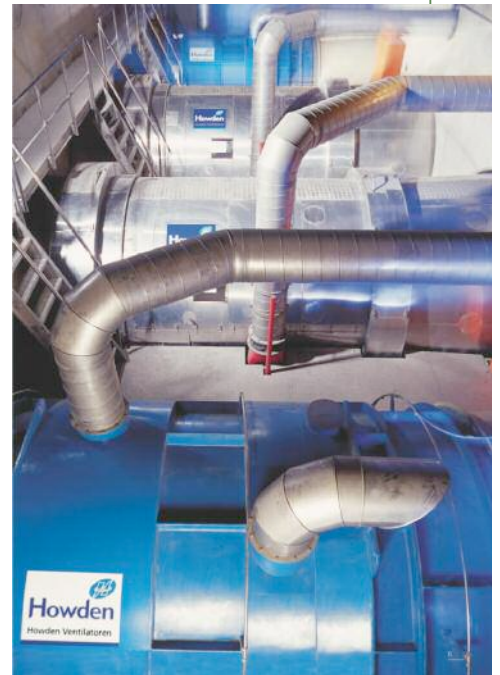
Higher rating

More accurate and demanding test fire profiles have led to requirements for fans, particularly in exhaust situations, that will perform longer in the event of a fire. In addition flow capacity requirements have often increased for rapid clearance of contaminants from road tunnels, but also from metro systems.

Flakt Woods, for one, has anticipated the need for larger fans, achieving EN12101-3 certification by successfully testing a 1MW axial fan of 2.24m diameter and running at 1500 rev/min. The fan range, of up to 2.8m diameter, can operate at 400 degrees C for two hours. The fan, with steel blades and steel hub, is the most highly stressed in the range with the greatest power requirement, allowing the test to cover the whole range. The manufacturer says, however, that though there is little actual requirements for a 1MW unit, with ever increasing performance boundaries, this is looking to the future in range terms.

Jet fans

A major development in road tunnel ventilation over recent years, at least for longitudinal movement, has been jet fans.



Above: Howden Ventilatoren fans in the north fan station of the Plabutschunnel

These work mainly by inducing airflow around them, multiplying the air actually passed through each fan. With a dedicated control system they can be effective in aiding smoke or fume control during emergency situations, especially when reversible drives are used, to limit the spread of the contaminants and improve the chances of a safe escape route. Usually used mainly in shorter tunnels (less than 3km long) where they can reduce the overall costs of a ventilation system, but can also be used in combination with more conventional major fan with shafts and or ducts. They also hold the possibility of easier flow control for varying traffic levels throughout the day.

Even now the actual mechanism of flow inducement does not appear to be completely understood, and the calculation and testing of fan capacity required has been called into question (see separate article this issue p33) resulting in excessive installations.

There have been a number of design improvements since the first introduction of jet fans, in order to reduce some of their disadvantages. As stated by Fathi Tarada, of Mosen and the developer of the recently introduced MoJet fan, these include:

- Loss of thrust due to 'friction' (Coanda effect),
- Large number of units required to generate sufficient thrust,
- Fans unit are large and heavy, 'leading to installation and maintenance challenges'.

The alternatives for longitudinal ventilation are Saccardo (impulse) nozzles (patented in 1898), and fans in ventilation shafts working on a push-pull effect, both of which can require substantial extra civils works for new or refurbished tunnels.

The Banana Jet, available from Witt & Sohn of Germany, improves on installation efficiency by having a housing that directs the jet towards the tunnel centreline at an angle of seven degrees instead of a straight tube. It can therefore have a major improvement when installed in a niche in the tunnel wall or crown. Up to 30 per cent more effective thrust is claimed compared to traditional jet fans of the same size.

Tarada claims that directing the jet away from the axis generates a 'wall jet' on the road surface, above which any smoke can move upstream, although the Coanda effect is reduced. In some cases the nozzles can encroach on possible traffic space he claims. The alternative of deflection louvers on the fan duct generates a large pressure drop, he points out, at both ends of the fan duct.

The Mosen MoJet, however, combines the advantages of jet fans and the induced flow of Saccardo nozzle installations by having convergent nozzles on one or both

ends of the fan. This gives accelerated flow and hence increased thrust (typically 7 to 20 per cent), and directs the flow to the tunnel centre-line to increase the installation efficiency (giving a further 18 to 37 per cent thrust increase). An overall thrust increase of up to 64 per cent may be available, Tarada claims. The nozzle reduces mass flow through the fan, but if the fan characteristic is 'steep' enough, this is compensated for by the increase in air velocity.

Metro ventilation

With the London Underground metro system, the fire at King's Cross-St Pancras station, and the multiple bombings of 2005 have affected the thinking on the necessary system ventilation in such a large network. In parallel with this scenario there is an underlying need to cool the system, particularly in summer and in overnight maintenance periods when ventilation by train movements have proved to be inadequate to prevent heat build-up and thermal radiation from the surrounding ground.

The major refurbishment scheme currently underway on the London Underground network includes ventilation renewal in various projects across most network routes. This includes a recent award to Mansell (Balfour Beatty Group) of a GBP 6.3M (USD 9.8M) second contract to upgrade four mid-tunnel ventilation shafts with new fans on the Victoria Line. The ventilation refurbishment, as well as providing emergency ventilation, is often, as with this concrete, also part of a scheme to reduce heat build-up in the underground rail network. The new contract is due for completion in November next year.

Dampers

Dampers or louver valves are the less glamorous but nevertheless vital component of tunnel ventilation systems where some degree of sealing off of passages is required, such as for emergency control of smoke extraction and fresh air redirection, or for maintenance.

As part of the Europe wide move to comply with EU Directive 2004/54EG, the ventilation of existing Trans European Network (TEN) road tunnels is being upgraded, and some other operators non-TEN routes.

The major highway crossing of the River Elbe in Hamburg is now comprised of four tunnels. Comprehensive refit of the first three bores was started last year including the retrofitting of 410 Trox dampers for smoke extraction for fire protection. They are made of stainless steel and can withstand 400 degrees C for 90 minutes.

Trox dampers are already fitted to the Mrazovka Tunnel in the Czech Republic and the Vielha Tunnel in Spain—the ventilation of both having been rated as 'very good' by ADAC, the German automotive society.

Another manufacturer, Connols-Air of Singapore supplies the OLS SD60 smoke dampers particularly for metro systems. It points out that dampers should have a fail-safe position during any power interruption and so must be tested within a ventilation system to prove reliability.

The damper is appropriate for automatic ventilation control from a central control using electric or pneumatic actuators. Stainless steel moving parts are employed to prevent seizure, within a galvanised steel structure. The louver blades are designed for high-pressure fluctuations and are tested to 6kPa. ▀



Above: A large Flakt Woods axial fan during certification tests



Above: Testing a MoJet fan



Above: Dr. Fathi Tarada

Breath of fresh air

Tunnels often have a bad name for air quality, some deservedly. A new report next year by the World Road Association (WRA), aims to set tunnel air quality standards for a range of airborne pollutants. Dr. Fathi Tarada, co-chairman of the WRA Working Group on Air Quality, Ventilation and Fire, also managing director of Mosen, explains

Tunnel ventilation systems are normally designed to maintain acceptable air quality and visibility levels during normal operation, and to control the spread of smoke in case of fire. While the fire case is often the dominating factor for highway and non-urban tunnels, in tunnels with a high traffic load and frequently congested traffic, the fresh air requirement for normal operation can be dominant. It is therefore important to consider the minimum fresh-air requirement required to ensure adequate in-tunnel air quality and visibility thresholds.

The main changes in the new WRA report comprise the inclusion of new emission data up to the year 2030, including the new emission standards EU5 and EU6. Light-duty vehicles will also be considered. The introduction of tighter emissions standards worldwide has resulted in reductions as new, lower emitting vehicles replace older, higher emitting vehicles. These changes are fully reflected in the new report.

For the first time, WRA will offer two calculation schemes for estimating vehicle emissions for a certain design year. One approach is based on a simple methodology using 2010 as the base year, adjusted with country-specific influencing factors concerning different design years, emission standards, etc. The country-specific factors are particularly useful in developing countries and countries in transition, where emissions data can be sparse. The second allows a detailed emission calculation based on vehicle-specific emission factors. However, this requires a detailed knowledge of the fleet composition for the design year.

Peak levels

The primary air quality criteria in the WRA report remain carbon monoxide (CO) concentrations and visibility limits, with no major changes proposed for design and

threshold (i.e., safety) levels. However, the report recognises the increasing importance of nitrogen dioxide (NO₂) as a pollutant in tunnels. Results of studies in which people have been exposed to NO₂ have demonstrated that this pollutant can negatively affect healthy as well as sensitive people. For healthy people, effects have been noted for peak levels higher than 4000 µg/m³; no effects have been observed for peak levels below 2000 µg/m³. Based on these findings, WRA proposes an in-tunnel air quality level of 1 ppm NO₂ as an average value. For comparison, the short-term (15 minute) occupational hazard limit set for NO₂ by the UK Health and Safety Executive in 2002 was 5 ppm.

The new report will offer guidance with respect to estimation of non-exhaust particulate matter emissions due to re-suspension and abrasion, although it recognises that there are large uncertainties in such estimations.

Stopped traffic and vehicle speeds around 10 km per hour typically define the normal ventilation capacity requirements. In longer tunnels, the ventilation equipment may be oversized if congested or stopped traffic is assumed over the entire tunnel length. Therefore, the report advises that it is preferable to prevent congested/stopped traffic over the full tunnel length by a traffic control system.

Many pointers are provided to guide the unwary in designing and operating tunnel ventilation systems. For example, the percentage of heavy goods vehicles in traffic is normally quoted as an average percentage of the total traffic flow. However, this value is normally too high when applied to peak traffic flow, and this may cause an over-dimensioning of the ventilation system.

Although the report focuses on the application of emissions standards, it is widely recognised that no matter how well a tunnel ventilation system is designed, it is important that it is operated properly in order to maintain a reasonable air quality both within the tunnel and also in the immediate vicinity of the portals. This requires reliable in-tunnel air quality measurement, and a responsive control system for the ventilation system.

System types

The new WRA report does not discuss the merits and drawbacks of alternative ventilation systems, since these have already been covered in previous publications. However, every ventilation system has its limitations, and these can complicate its operation and control during congested periods. For example, semi-transverse ventilation systems such as those employed in older London tunnels including the Rotherhithe Tunnel have 'dead zones' where the longitudinal air velocity is close to zero, and the concentrations of pollutants are therefore high. Longitudinal ventilation systems with jettans or Saccardo nozzles do not have this drawback, but generally have their highest pollution concentrations at the discharge portal. Fully-transverse ventilation systems can provide a high level of air quality throughout the length of a tunnel, but are by far the most expensive option in terms of construction and operating costs.

Through an improvement in the design, operation and control of tunnel ventilation systems, we can look forward to a day when we can breathe easily while driving through tunnels, and when tunnels finally lose their poor reputation for air quality. The new WRA report may allow us to go one step closer towards that goal. ■



OSTU 
STETTIN

**STEEL
AND
FORMWORK**
www.tunnelschalung.at

OSTU 
STETTIN **STEEL
AND
FORMWORK**
www.tunnelschalung.at

CONSTRUCTION UNLIMITED

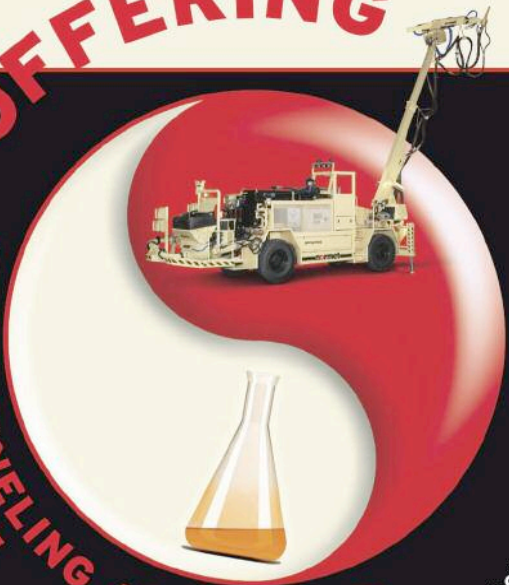
ÖSTU - STETTIN Hoch- und Tiefbau GmbH
 Münzenbergstraße 38 / A - 8700 Leoben
 Tel.: ++43 (38 42) 4 25 23
 Fax: ++43 (38 42) 4 25 23 -142
 E - Mail : schalungsbau@oestu-stettin.at



www.normet.fi

normet
 FOR TOUGH JOBS

PROCESS OFFERING
FOR TUNNELING AND MINING



> More than 60 countries being served
 > More than 45 years of experience

www.coray.com



Jet fans: Removing non-conservatism from the CFD modelling

The authors, Marco Buonfiglioli, Ian Cowan and Stig Ravn, all of Atkins, Epsom, England, presented a poster at the ISTSS event in Frankfurt am Main, Germany, earlier this year on an improved approach to jet fan performance modelling. This is the full paper

CFD (Computational Fluid Dynamics) is commonly applied to verify the performance of ventilation systems in road tunnels and their ability to control smoke from vehicle fires. Often, such tunnels rely on jet impulse fans to induce air and smoke movement in the tunnel. These types of fans, however, are highly focussed in their effect, and so any modelling approach must provide an accurate prediction of the rate at which the high-speed jet flow from the fans mixes with the slower surrounding air. Over-prediction of the jet spreading rate will lead to optimistic (non-conservative) predictions of the velocity at the tunnel mid-plane, and therefore will give misleading indications of the efficiency of the ventilation system.

This paper will use existing knowledge of CFD and turbulent jets (i.e., ref 1) and use example CFD simulations to show the current approach that is widely used in this industry (namely a k-epsilon turbulence closure model with relatively coarse grid resolution levels) is inadequate to provide accurate predictions for these types of flows, and will in fact often lead to non-conservative designs. Finally, we will present a more appropriate CFD approach, based on enhanced modelling techniques and current 'best practice,' that we believe should form the basic standard for the modelling of such flows.

Smoke in tunnels is often controlled by using a longitudinal airflow in the tunnel to prevent smoke backlayering and to push smoke forward, thus creating a clear path for evacuation and access to the incident for the fire brigade. The magnitude of this flow is often referred to as the 'Critical Velocity' [ref 2]. Several different means can be used to generate this flow, axial fans, Saccardo nozzles or jet fans. This paper will focus on the last as jet fans are the most commonly used method, and they raise a number of key issues with their modelling.

Traditionally one-dimensional numerical modelling is applied for simple tunnel geometries, when designing the tunnel

ventilation system for normal and emergency operations since it is rapid and effective. Nevertheless, for the verification of the ventilation system, for more complex geometries and for scenarios where the efficiency of the fans becomes paramount, the more resource intensive approach of three-dimensional CFD modelling is often necessary in order to show the full flow picture and to predict the smoke control performance of tunnel ventilation systems.

Jet (impulse) fans work by transferring momentum from their high speed jet to the relative slow tunnel air, and so the modelling of the ventilation flow must provide an accurate prediction of the rate at which the jet flow from the fans mixes with the background air. This is particularly important for tunnels of high aspect ratio where the fans are located at the edges of the tunnel (i.e., not over the carriageway) since there is a tendency for the air in the centre of the tunnel to stagnate or even to reverse direction. Accurate modelling means applying the most appropriate tools for the numerical model such as addressing the correct turbulences model and mesh size (see ref 3 for best practice guidelines).

The following case study will use existing knowledge of CFD and turbulent jets (i.e. ref 1) to highlight the issue, and focuses on the simulation of high aspect ratio tunnels with jet-fan ventilation systems. The aim is to draw attention to how the widely used approach in this industry (namely a k-epsilon turbulence closure model with relatively coarse grid resolution levels) is inadequate in providing accurate predictions for these types of flows, and will in fact often lead to non-conservative designs and overconfidence in the proposed ventilation setup.

Case study

Results are presented here from a CFD assessment of the smoke control performance for a 1,150m long road tunnel equipped with angled jet fans. The tunnel section has an aspect ratio of 3.8:1 (width:height) and is 19m wide. The

modelled fire scenario is as follows:

- 50MW total fire power, including radiation (which is assumed to be 30 per cent of the fire power),
- Fire located 85m from the exit portal,
- Stationary traffic all along the tunnel up to the fire location,
- Jet fans located at the upper edges of the tunnel.

For modelling purposes, only the last 350m of tunnel have been modelled. A total pressure boundary has been applied at the model inlet; the pressure value has been derived accounting for the modelled length of the tunnel.

The fire is located 260m downstream of the model inlet, which is sufficient to achieve a fully developed flow field at the fire location. All walls are no slip, impermeable rough walls, with high Reynolds number wall functions. Each jet fan has been explicitly modelled by a pair of positive and negative velocity inlets representing the fan intake and exhaust surfaces. Swirl effects in the jet have been neglected in this study.

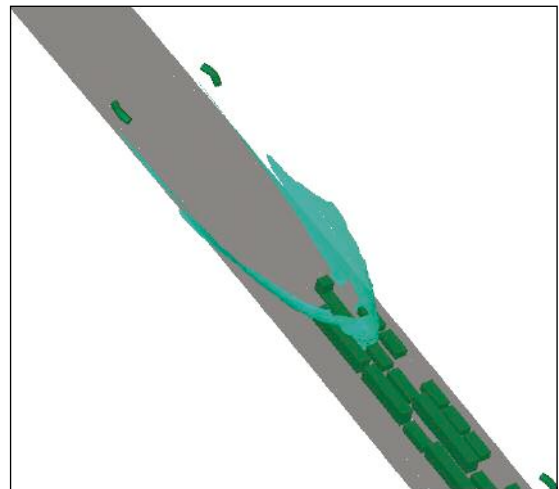
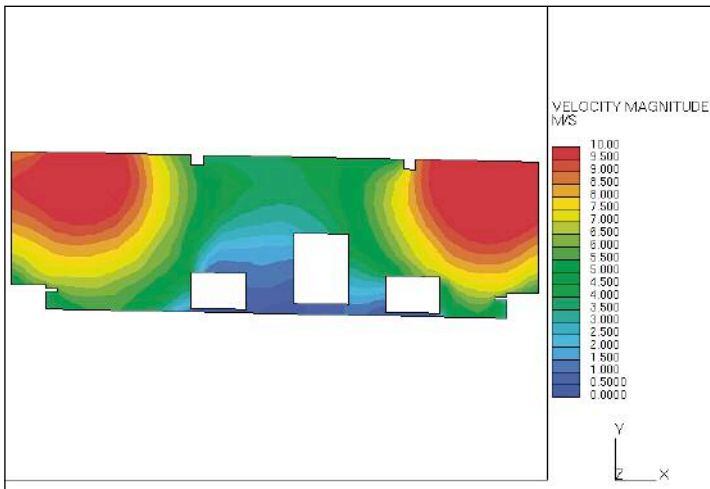
Ten per cent of the fans upstream of the fire have been assumed not to be working, due to redundancy requirements in the system design. The pair of fans downstream of the fire has been assumed not to be working due to the high temperature. The vehicles (a mixture of cars and HGVs giving 165 PCU/km [ref 4]) have been modelled as solid blockages.

Radiation effects have not been explicitly modelled, for simplicity, so only the estimated convective part of the fire power (35MW) has been accounted for.

Analysis

The CFD analysis has been carried out taking two different approaches:

- 'Industry standard' approach, where a relatively coarse mesh and a linear turbulence model have been used;
- 'Best practice' approach, where a suitably fine mesh and a more appropriate turbulence model have been used.



Industry standard approach

In this simulation, the following approach was taken:

- 1.1 million cells mesh, with a base grid cell size of 0.75m;
- Standard linear, buoyancy-enhanced k-epsilon turbulence model.

The mesh is relatively coarse with no refinement in the jet expansion zone. The linear k-epsilon model is probably the most widely used turbulence model in any industry, is the default closure model for most CFD codes, and is often applied indiscriminately to any application without fully understanding its pitfalls.

The results from the simulation are summarised in Figure 1, which shows the velocity magnitude in a cross section halfway between a pair of fans and the extent of the smoke spreading. These plots suggest that the ventilation system is effective in generating a relatively strong, down-tunnel ventilation flow which is sufficient to control the smoke and prevent

any upwind migration of smoke from the fire source.

Best practice approach

The analysis has been carried out taking an approach that makes use of best practice for CFD, and so invariably requires more computational effort:

- 13.5 million cells mesh, with a base size of 0.2m,
- Quadratic, buoyancy enhanced k-epsilon turbulence model.

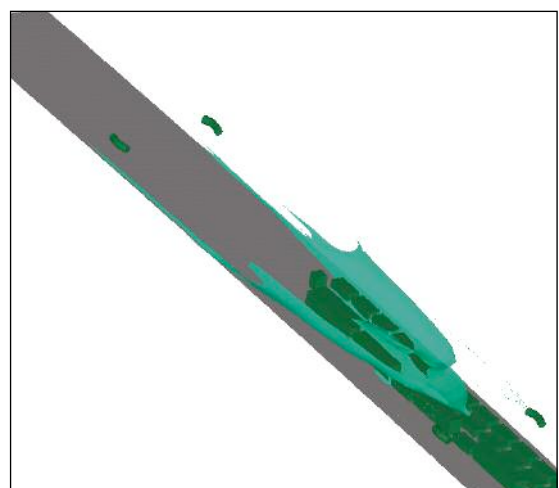
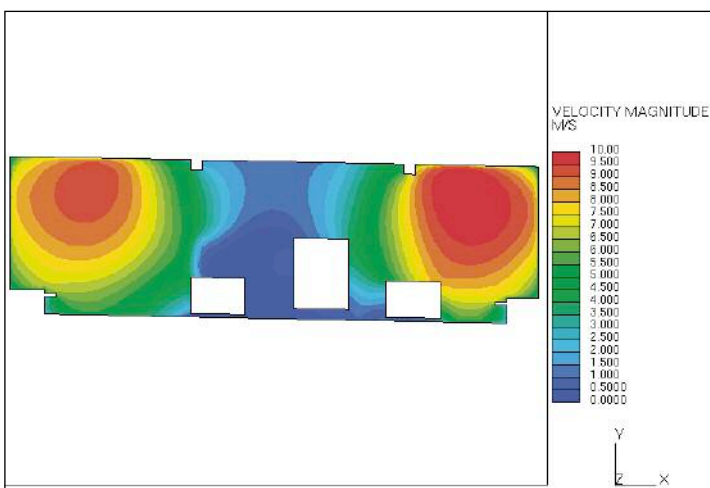
The mesh is a fine, high quality mesh with several levels of refinement in the jet expansion zone. The quadratic k-epsilon model has been chosen as it can correctly capture the most important feature of the flow, namely the round jet expansion ratio. The ERCofact Best Practice Guidelines (ref 3 – European Research Community On Flow, Turbulence And Combustion) clearly state that “when using a particular turbulence model, check the published literature with regards to the known weaknesses of the

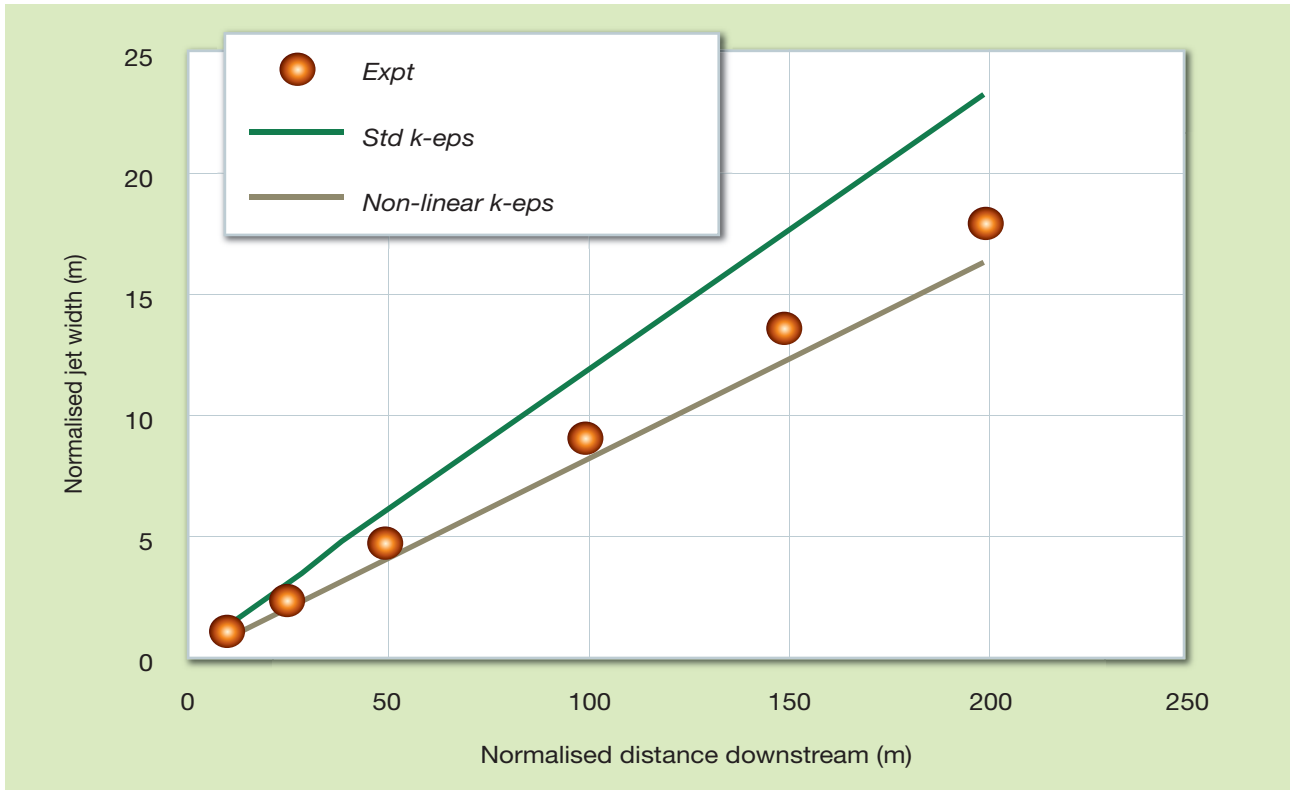
Above: Figure 1 – Industry standard approach results. Velocity magnitude halfway between a pair of fans (left) and smoke extent (right)

model,” and also that “grids must be fine enough to provide an adequate resolution of the important flow features.”

The above choices were made on this basis. The results from the simulation are summarised in Figure 2 and suggest a different picture; namely that the spreading rate of the jet momentum is not sufficient to ensure a consistent, down-tunnel ventilation flow. This means that the central portion of the tunnel does not achieve the critical velocity airflow, the fan efficiency is reduced because of the higher velocity at the fans inlets and, as is shown by the fire simulation, cannot prevent

Below: Figure 2 – Best practice approach results. Velocity magnitude halfway between a pair of fans (left) and smoke extent (right)





Above: Figure 3—Graph of predicted spreading rate for turbulent, round, free jets with standard and non-linear k-epsilon closure models, compared to experimental test data.

back-layering of the smoke. This is a different picture from the previous section, and would lead the tunnel designers to seek modifications and improvements to the ventilation design.

Comparison of approaches

The previous sections have shown that very different conclusions would be drawn from the two different approaches. The difference can be explained by Figure 3, which shows the predicted spreading rate of a round, free jet for two different turbulence models. It has been known for a long time (ref 1) that the linear k-epsilon model over-predicts the spreading rate of round jets due to a deficiency in the turbulent dissipation for this type of geometry.

Hence, in the industry standard approach there are two mechanisms that work together to artificially spread the momentum effects across the tunnel—the coarse nature of the grid and the poor performance of the selected turbulence

model. This leads to a mistaken conclusion that the ventilation system is performing well. Use of best practice, and more computational resources, provides a more faithful picture of conditions in the tunnel and finds that the ventilation system needs improving.

Conclusions

Two CFD fire simulation analyses have been carried out of the same scenario by taking the industry standard approach (coarse mesh, and a linear k-epsilon closure model) and the best practice approach (fine mesh and appropriate turbulence model). The analyses show contrasting results; the industry standard approach finds that the ventilation system is able to control smoke, while the best practice approach shows that backlayering occurs.

The difference is caused by the flaws of the industry standard approach, which leads to erroneous predictions of the ventilation flow field and non-conservative

conclusions for cases where the prediction of the jet spreading rate is critical to the ventilation system performance. This is particularly true for large aspect ratio tunnels with jet fans installed in the corner, although on a more general note, computing power is now sufficiently available at a reasonable cost for 'best practice' to be applied whatever the geometry.

Authors

The authors are all with Atkins:

- Marco Buonfiglioli MEng(Hons) CEng MIMechE - senior engineer, energy;
- Dr. Ian Cowan - chief engineer, fluid mechanics, energy;
- Stig Ravn - principal engineer, tunnelling

References

1. Pope, SB. 'Explanation of the turbulent round-jet/plane-jet anomaly', AIAA Journal, 1978
2. National Fire Protection Association NFPA502. 'Standard for Road ~Tunnels, Bridges, and Other Limited Access Highways,' US, 2008
3. ERCofac (European Research Community On Flow, Turbulence And Combustion) 'Best Practice Guidelines for CFD,' January 2000
4. PIARC (World Road Association). 'Road Tunnels: Vehicle Emissions and Air Demand for Ventilation,' 2004

Acknowledgement

Tunnels & Tunnelling International is grateful to the authors and to SP Technical Research Institute of Sweden for permission to publish this paper in this form. It was first presented as a poster at the 4th International Symposium on Tunnel Safety and Security, Frankfurt am Main, Germany, 17-19 March. Full proceedings are available. See www.sp.se.

Looking for a career change?

You have a degree in civil engineering, mining or metallurgy, with a minimum of 5 years experience in one of the following areas: construction of large civil engineering projects / erection or operation of metal processing or mining facilities / loss adjustment or risk inspection of such projects and facilities

You would like to make a career move where your engineering experience can be used to assess the financial consequences of risks in a world with which you are familiar.

We are a successful insurance company specialized in insuring the construction and operation of major, international infrastructure projects and facilities.

Our company is based in Zurich, Switzerland and extends its business activities throughout the world.

For further information concerning career opportunities within our organization please go to www.infrassure.com

infrassure
energy and infrastructure insurance

Infrassure Ltd. is a Swiss registered company with a rating of A- (Excellent) from AM Best.

www.infrassure.com



a touch of respect

Focus 2011
Sustainable Construction

Samoter

28th International Triennial Earth-moving and Building Machinery Exhibition
2nd - 6th March 2011 Verona, Italy

www.samoter.com

- earth-moving
- concrete
- road
- drilling
- quarrying
- lifting
- vehicles
- components

- rental area
- demo area

sponsored by
CECE

organized by
VERONAFIERE

There must be a better way

Ground conditions and risk allocation: Combining the NEC Engineering and Construction Contract (ECC) and the Geotechnical Baseline Report (GBR). Article by Randall Essex, director of tunnelling, Hatch Mott Macdonald; and from Mott MacDonald, Richard Patterson, NEC and procurement specialist; Ian Duncan, geotechnical specialist and Andrew Hindmarsh, senior project manager

Since its introduction fifteen years ago the NEC Engineering and Construction Contract (ECC) (ref 1) has been successfully used across all sectors in the UK, and elsewhere in the world such as South Africa, Dubai and Australasia (ref 2). Beginning in the 1970s, tunnelling personnel in North America have evolved the concept of Geotechnical Baseline Reports (GBRs) (ref 3) for application to underground works. The combination of these two best practice tools offers real benefits to all parties to a construction contract involving significant excavation and/or groundworks (tunnels, shafts, soil stabilisation, ground remediation, deep excavations, etc.). This article explains in more detail how the NEC and the GBR concept can be combined to more clearly allocate ground risk.

The article follows an excellent, more general article entitled 'Managing Ground Risk' (ref 4, *T&T* September 2010, p46)

NEC contracts and risk

The NEC contracts are specifically designed for clarity and flexibility, and to stimulate good management. This is one reason why they are specifically endorsed by the UK's Office of Government Commerce as meeting its 'Achieving Excellence in Procurement' guidelines and are also endorsed for use by the South African Government. The NEC was used for the Channel Tunnel Rail Link in the UK and is to be used for Crossrail (ref 5). While other forms of contract have continued to be used successfully, the NEC contracts address risk allocation and risk management particularly well (ref 6, 7).

It should be noted that NEC contracts are very different from traditional contracts. They are effectively a series of processes to actively manage a project. Adjustments in training, systems, and culture are required to make them work well.

The main project contract within the NEC family is the NEC ECC. This is modular in structure and provides options for lump sum, remeasurement (bill of quantities), target cost and reimbursable contracts. All

specific events that a bidder is not required to price because they are to be at the risk of the employer are identified as 'compensation events.' These items are managed through a process whereby the forecast cost or schedule impact, if any, is agreed and then compensation is made.

Where the employer's requirements are difficult to define or cannot be defined it is good practice to include in the 'Works Information'—the document that sets out requirements for the works and constraints on how the work is to be performed—stated assumptions upon which bidders should base their price and programme. These assumptions act as baselines. If an assumption later proves to be incorrect then the Works Information will be corrected to reflect the actual circumstances. This change then triggers a compensation event.

Previous experience with GBRs

Dating back to the 1970s, tunnelling professionals in North America recognised the importance and value of including an interpretive geological/geotechnical report in construction contracts involving underground works. The desire to create such documents grew from an increasing trend toward disputes and litigation. Previous practice involved the preparation of one or more reports containing factual and interpretive information, and making those reports available to the bidders 'for information purposes only.' Bidders were warned that they were not to rely on such information, but at the same time, were to make their own interpretations of the site and subsurface conditions in a low-bid environment. Such practices generated ambiguity under the construction contract, with an increasing tendency toward protracted litigation that extended years beyond construction completion. The only entities to benefit were the parties' legal representatives.

The content and focus of contractual interpretive reports have evolved over the years. The North American tunnelling industry now refers to this document as a GBR. As stated in an ASCE (American Society of Civil Engineers) Guidelines Publication on GBRs

(ref 3), the aims of the GBR are to provide:

- a concise overview of the project;
- the anticipated relevant physical conditions to be encountered with reference to details contained in a Geotechnical Data Report (GDR);
- and the anticipated ground behaviour consistent with certain assumed construction approaches, means, and methods.

The GBR addresses the range of uncertainty demonstrated by the available data, but then states, for contracting purposes, the baseline averages and ranges that are contractually binding. This eliminates a substantial degree of the ambiguity that existed when it was left to bidders to make their own interpretations. Under a traditional design-bid-build framework, the GBR is prepared on behalf of the owner (often the 'employer' under the contract). Under a design-build framework, a collaborative process can be employed that incorporates input from the design-build team as well as the owner in advance of signing the final contract.

In North America, the clause typically invoked is known as the 'Differing Site Conditions (DSC) Clause,' whereby the contractor is entitled to additional compensation if:

- it reasonably relied on an indication in the Contract, and,
- as a result of encountering a condition more adverse than indicated in the contract, it has experienced an increase in the cost or time of the work.

Under the 'old' method, if the geological/geotechnical reports were specifically excluded from the contract (i.e., for information only), and bidders were to make their own interpretations of the anticipated ground conditions, the administration of the DSC clause was fraught with ambiguity, conflict and protracted disputes. Clause 12 of the ICE (Institution of Civil Engineers) Conditions of Contract invokes a somewhat different standard, that is, what an experienced

contractor might have foreseen. Despite the different tests, there have been a number of infamous Clause 12 disputes (ref 8). The ICE has now withdrawn support for its own 'ICE Contracts.'

From a contractual perspective, if the contract says that the contractor is entitled to additional compensation if the encountered conditions are different than those indicated in the contract, the content of a GBR is intended to answer the question: Different from what?

Some owners have expressed that they believe they are entitled to a credit if the actual conditions encountered are more favourable (and therefore less costly) than the contractual baselines. However, the bidder takes on additional risk if it bases its bid on conditions more favourable than those indicated in the baselines. If the baseline conditions are encountered, the contractor is not entitled to any additional compensation. Similarly, if the conditions encountered are more favourable than those portrayed in the baselines, neither party is entitled to a renegotiation, whether the contractor had assumed more favourable conditions or not. In a competitive bidding environment, the contractor assumes the risks, and the owner realizes the benefits. If the conditions are comparable to or more favourable than the stated baselines, risk and reward both accrue to the contractor.

To avoid contractual 'gamesmanship,' the ASCE Guidelines recommend that baselines be prepared that are realistic and not overly conservative. From an owner's perspective, the less onerous the assumed baseline conditions, the more likely it will benefit financially if better conditions are realised. Viewed from another perspective, overly adverse baselines will serve to raise the cost of construction whether the adverse conditions are encountered or not, but will not necessarily eliminate the potential for disputes.

Given the inherent uncertainties involved with underground construction, it is not uncommon for disputes to develop that require resolution by an adjudication panel. The parties have generally accepted the rulings of such panels, which has served to remove protracted legal battles from the contracting landscape. Thus, the use of GBRs, in conjunction with adjudication panels, is achieving the desired goal. Under the philosophy of continuous improvement however, the industry can always do better. An underlying premise for the second edition of the ASCE Guidelines Publication was to capture and share lessons learned from past practices. It is hoped that through

this process better, clearer GBRs are written, construction risks are more effectively identified and priced, contractors are paid fairly for the work they must perform and disputes in the underground industry are reduced.

GBRs outside of North America

Since its initial use in North America, the concept of a GBR has spread worldwide and has successfully proved its value on projects in Hong Kong, Singapore, Australia, New Zealand, Europe and the UK. The ASCE Guidelines Publication has recently been translated into Japanese, and a similar effort is underway for translation into German. In the UK, a GBR is being used on Thames Water's Lee Tunnel contract and GBRs will be prepared for the Crossrail underground contracts. Many clients and contractors are now insistent on the use of a GBR, having seen the benefits in terms of surety of cost on behalf of the former, and contractual fairness on behalf of the latter.

Insurance industry and risk

In association with the British Tunnelling Society, the Association of British Insurers developed and published 'The Joint Code of Practice for Risk Management of Tunnel Works in the UK' (ref 9) in 2003, and an international version in 2006 (ref 10).

Recognising the importance of properly managing the risks associated with underground works, these codes feature two fundamental approaches to improved identification, minimisation, allocation and management of risk:

- the implementation of risk registers, to facilitate the identification, allocation, and management of risks during project planning, design and construction in a pre-emptive manner; and
- the preparation and implementation of a 'Ground Reference Conditions' Report or 'Geotechnical Baseline Conditions' Report that sets out the employer's understanding of the anticipated conditions.

The UK and international code versions give additional details relative to the development and implementation of the risk register process. Of relevance here are the codes' explicit endorsement of a process whereby the employer carries the responsibility of completing a thorough site exploration program prior to tender, presents the results of the exploration in a geotechnical data report that is included in the contract and then takes contractual and financial responsibility if the conditions encountered are more adverse than those

documented as the ground reference conditions. The 2003 UK code cites the first edition of the ASCE Guidelines Publication on GBRs (published in 1997) as one example of a Ground Reference Conditions Report approach. The insurers and the British Tunnelling Society recognised the merit in using a GBR as a key tool in the overall approach to allocating and sharing risks between the contracting parties.

Standard physical condition risk allocation

The contracts in the NEC family strive to be precise on the matter of risk allocation. For example the default risk allocation in the NEC ECC (ref 11) relating to weather has the employer taking the risk if certain defined weather measurements are more adverse than the 1 in 10 year event. This is a great improvement on the vague 'exceptionally adverse weather conditions' clauses in many contracts.

Being precise regarding physical conditions is a bit more challenging. The default risk allocation in the ECC is set in clauses 60.1(12), 60.2 and 60.3. The following three tests have to be passed in clause 60.1(12) for physical conditions to be a compensation event:

"The Contractor encounters physical conditions which

- are within the Site
- are not weather conditions and
- an experienced contractor would have judged at the Contract Date (ref 12) to have such a small chance of occurring that it would have been unreasonable for him to have allowed for them.

Only the difference between the physical conditions encountered and those for which it would have been reasonable to have allowed is taken into account in assessing a compensation event."

Clause 60.2 then states:

"In judging the physical conditions for the purpose of assessing a compensation event, the Contractor is assumed to have taken into account:

- the Site Information
- publicly available information referred to in the Site Information
- information available from a visual inspection of the Site and
- other information which an experienced Contractor could reasonably be expected to have or to obtain."

The 'Site Information' (defined in Clause 11.2 (16)) is "information which

- describes the Site and its surroundings
- is in the documents which the Contract Data states it is in."

Hence Clause 60.2 requires the bidder (and later the contractor) to take into account the 'Site Information' in judging the physical conditions. As is the case with any contract where physical conditions are important, and in consideration of the Joint Code of Practice discussed above, the employer is well advised to invest at least in quality factual information about—for example, ground conditions and existing services—to allow all parties to assess the risks associated with physical conditions. The appropriate place for this information in an ECC contract is very clearly in the part entitled 'Site Information.' Indeed the only references in the contract to this Site Information relate to physical conditions and hence, ultimately to the decision as to whether a certain occurrence is a compensation event.

Clause 60.3 is the last of the clauses to refer to Site Information. It states:

"If there is an ambiguity or inconsistency within the Site Information (including the information referred to in it), the Contractor is assumed to have taken into account the physical condition more favourable to doing the work."

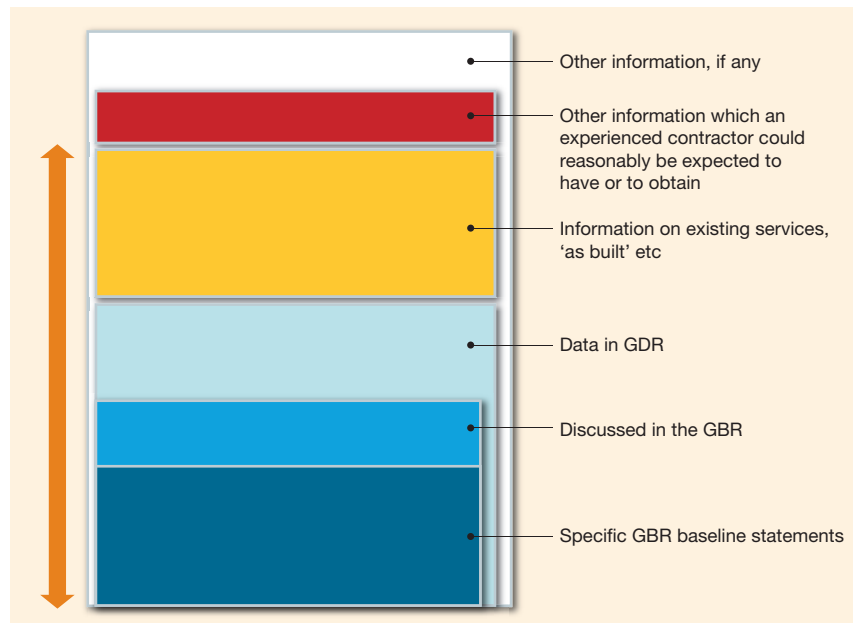
This is effectively the 'contra preferentem' rule: the owner/employer has (normally) prepared the Site Information and takes the risk of ambiguities or inconsistencies within it.

Importantly, with respect to time, compensation events can lead only to a delay to the required 'Completion Date' – they cannot bring the Completion Date forward (Clause 63.3). Also only certain stated compensation events can result in a reduction to the 'Prices' (the ECC equivalent to the 'contract price'). The physical conditions compensation event is not one of them (ref 13). So, if the contractor encounters conditions better than expected, the Prices are not reduced.

Unfortunately, the interpretation of the phrase *'physical conditions which...an experienced contractor would have judged at the Contract Date to have such a small chance of occurring that it would have been unreasonable for him to have allowed for them'* is overly subjective and more appealing to lawyers than to tunnelling and geotechnical engineers. For a project involving significant excavation, there must be a better way.

Combining GBR with NEC ECC

The standard ECC clauses for physical conditions may be appropriate for most projects. If underground works are a



Above: Figure 1—Information about particular aspects of physical conditions for contractual purposes (schematic only) [Mott MacDonald]

significant part of the project however, it may be appropriate to make more direct reference to a GBR in the contract.

If the GBR is included in the Site Information and if it states certain assumptions to be made (baseline statements), then those assumptions will, because of Clauses 60.2 and 60.1 (12), logically form the agreed baseline for pricing by the bidder.

It is suggested that if the bidder were told in the Site Information to make a certain assumption, then given the last sentence in 60.1(12), it would be difficult for an employer to later suggest that the contractor should have allowed for something else.

The challenge is how to clearly link the compensation event definition to the baseline statements. To match the ECC provisions in Clause 60.1(12) (physical conditions) and 60.1(13) (weather) a sentence regarding the assessment of such an event should also be included.

The simple result in Option Z (additional conditions of contract) might be along the lines of:

"Add as Clause 60.1(12A) (ref 14):

- The Contractor encounters conditions (ref 15) that are the subject of a baseline statement in the GBR included in the Site Information that are more adverse than the baseline statement
- Only the difference between the conditions (ref 15) encountered and the baseline statement is taken into account in assessing a compensation event."

It would also be sensible to amend Clause 60.1(12) (above) to start with: "The Contractor encounters physical conditions other than those which are the subject of a baseline statement in the GBR." In this way the risk allocation for issues not specifically addressed by GBR baselines would remain as per the standard ECC risk allocation. It might, however, also be necessary to consider the last bullet point in Clause 60.2 (above). Having gone to the trouble of preparing a GBR, is it really appropriate to 'reasonably' expect the bidder to have or to obtain other information?

The risk allocation relating to a certain parameter or condition would depend on how the parameter or condition was baselined in the GBR, e.g., a specific value, a range in values or a range in likely behaviours.

For example, the baseline statements in the GBR might include:

- Assume parameter A is value X or less
- Assume ground condition M occurs at a frequency Y between locations P and Q.

The contractor then takes the risk (ref 17) of:

- The parameter A being less than or equal to X and
- the occurrence of ground condition M up to frequency Y within locations P and Q;

If more favourable conditions make things easier for the contractor, then he will get all the benefit in a priced contract, as discussed earlier in this paper (if this

reduced the contractor's costs, the 'Prices' would not be reduced [because of Clause 63.2 as described above]). With a target contract, the benefit will be shared. If the employer did want the Prices to be reduced for 'better than assumed' parameters, it could do so under Option Z, though quantifying the benefits would be difficult.

In all cases, it is beneficial to be clear in the contract (the Works Information in the ECC) on how, where, when and by whom the actual conditions encountered will be verified. If this is the case, the occurrence or otherwise of a compensation event will be most easily identified and agreed. However, the 'burden of proof' will still be with the contractor to demonstrate the 'adverse effect'.

Exactly how these risks are allocated and the parameters selected will need to be discussed between the employer and his specialist geotechnical advisors and, in some cases, with pre-qualified bidders.

Figure 1 (p39) from Mott MacDonald illustrates the various information about physical conditions discussed in this article

and those parts that could be included in the ECC's Site Information.

Summary

Where used, the GBR has become a key contract document for a project including major excavation or underground works. It is often the first document to be read by bidders and, in the event of a dispute, the first to be revisited by the client's representative or adjudication panel. As a result, the preparation of a GBR requires specialist experience and skill in its preparation.

Numerous heavy civil and underground projects are due to be constructed worldwide. It is believed that for these projects, a properly thought-through GBR is a beneficial investment for a client to give surety of costs. Similarly, potential bidders may be more inclined to tender the work if they perceive that the GBR lends an added degree of fairness under the contract.

As a ground reference report is called for under the Joint Code of Practice⁹, the insurance industry demands that such a document is prepared and included in the

contract as a condition for making insurance available to the project's contractor (All-Risk Policy or Performance Bond) or owner (Owner Controlled Insurance Programs).

Making sure that the baseline statements set out in the GBR are realistic, and link directly into the contract and associated payment provisions provides for more sensible and comparable bids from interested and competent contractors. It also provides for greater clarity in risk management and risk allocation. This in turn leads to an increased likelihood of a successful outcome for all involved. The same principles might also be applied, for example, to environmental aspects of a project with a potentially significant effect on a bid price.

The NEC ECC is increasingly being favoured by many clients worldwide. The clarity of the compensation events for risk allocation and management, linking to the appropriate use of the principles of the GBR, represents an evolving best practice in the contractual allocation and management of geotechnical risk. ■

Footnotes & references

1. NEC (formerly New Engineering Contract) is a family of contracts that facilitates the implementation of sound project management principles and practices as well as defining legal relationships. It is suitable for procuring a diverse range of works, services and supply spanning major framework projects through to minor works and purchasing of supplies and goods. The NEC vision is to become the global leader in promoting best practice procurement of works, services and supply. For further details see www.neccontract.com

2. Patterson, RL (2009). 'Use of the NEC outside UK jurisdiction', NEC Users Group Newsletter, No.47, March 2009

3. Essex, Randal J (Ed.) (2007). 'Geotechnical Baseline Reports for Construction, Suggested Guidelines', American Society of Civil Engineers, 2007

4. Legge & Suttie (2010). 'Managing Ground Risk', Tunnels and Tunnelling International, Sep 2010, p46

5. 'Crossrail' is a GBP 16-billion (USD 25.6-billion) railway project including extensive tunnelling under London.

6. Paterson, RL (2007). 'NEC and Risk Management', NEC Users Group Newsletter, No.40, Oct 2007 at <http://www.neccontract.co.uk/documents/NEC%20Newsletter%20Issue%2040.pdf>, accessed 1 September 2009

7. Patterson, RL (2009), 'Using NEC contracts to manage risk and avoid disputes', Management, Procurement and Law, No 4, 2009.

8. In August 2010, the Institution of Civil Engineers formally withdrew its support for its own 'ICE contracts' in favour of NEC contracts.

9. British Tunnelling Society (2003). 'The Joint Code of Practice for Risk Management of Tunnel Works in the UK' BTS, London, 2003.

10. (The) International Tunnelling Insurance Group (2006). 'A Code of Practice for Risk Management of Tunnel Works', BTS, London, 30 January 2006.

11. 'NEC Engineering and Construction Contract (ECC3), 3rd edition (2005). Thomas Telford, London, 2005.

12. 'Contract Date' in the ECC is the date that the contract came in to effect.

13. This is made clear in Clause 63.2 in the core clauses and Clause 63.10 in the priced contract options and in Clause 63.11 in the target contract options.

14. The event has to be made a compensation event. If the employer chooses to insure this event, it should be stated instead as an 'Employer's risk' (ref Clause 80.1). See note [5].

15. The guidance for the preparation of GBRs (footnote 3) differentiates between 'physical' and 'behavioural' ground conditions. It is suggested that the simple 'conditions' is used here, leaving the GBR to define the type of condition forming the baseline.

16. This is a slight simplification. Here 'takes the risk' means 'there will be no compensation event' if the risk event happens. The contractor then takes the risk regarding time: if there is no compensation event, there can be no delay to the contractually required Completion Date. However, the flexibility of the ECC allows for a choice of different payment options to be selected for a particular contract including lump sum, remeasurement, target and reimbursable. The choice of this option will affect the level of the financial consequences on the employer of the actual conditions encountered, the costs to the contractor and the amount to be paid by the employer. If there is no compensation event then there can be no increase in the lump sum or target price. In this case if the contract is lump sum, the full financial risk is with the contractor. If the contract is a 'target contract' then, although the target will not be changed, the employer will still be obliged to pay the contractor's costs of dealing with the occurrence. The result for both contractor and employer is that the opportunity to share in savings compared with the target is reduced. The target contract gives a commercial incentive to the employer to collaborate.

De Neef **REACHes** for the future

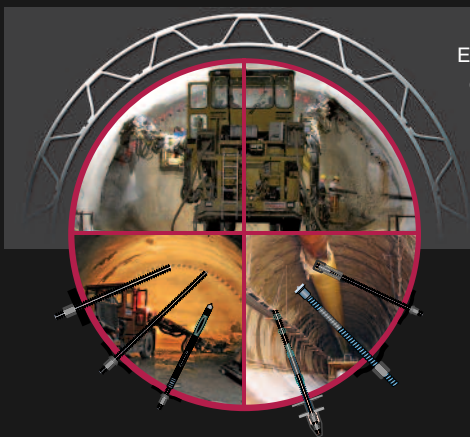
and introduces phthalate free PUR injection resins

REACH compliant • Hazard-free transport • Improved performance • Higher efficiency • Assured quality



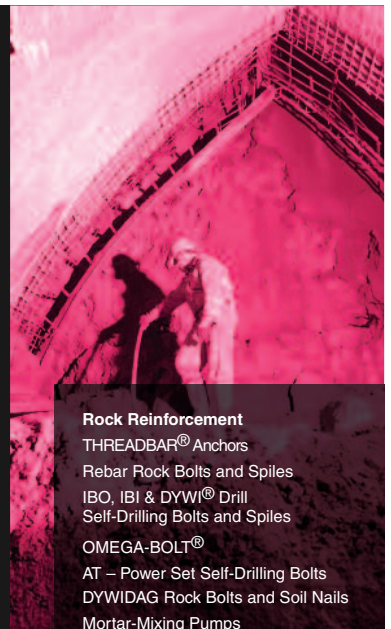
U.S.A • Spain • Belgium • Sweden • France • Germany • Portugal • www.deneef.com • U.K. • Switzerland • Finland • P.R.China • Hong Kong • Singapore

GROUND CONTROL SOLUTIONS



Each tunnel has a different geology and requires specific customized products and systems. DSI Tunneling Products and Systems match these requirements perfectly.

Our extensive R&D activities guarantee innovative, flexible and reliable underground support products to control every imaginable condition. We offer a complete line of high-quality ISO 9001:2000 certified and patented products. DSI is a leading company in the development, production and application of ground control solutions for the tunneling market. In line with our strong service approach, we are always committed to satisfying our customers' demands.



Rock Reinforcement

- THREADBAR® Anchors
- Rebar Rock Bolts and Spiles
- IBO, IBI & DYWI® Drill Self-Drilling Bolts and Spiles
- OMEGA-BOLT®
- AT – Power Set Self-Drilling Bolts
- DYWIDAG Rock Bolts and Soil Nails
- Mortar-Mixing Pumps

Rock Support

- Steel Arches and TH-Beams
- Liner Plates
- Pantex® Lattice Girders
- AT – LSC-Elements
- Lining Stress Controllers

AT – Casing System

- AT – Pipe Umbrella Support System
- AT – Drainage System
- AT – GRP Injection System

DYWIDAG-SYSTEMS INTERNATIONAL



Local Presence – Global Competence

www.dsi-tunneling.com

ALWAG SYSTEMS

North America

DSI Underground Systems Inc.
3900 West 700 South
Salt Lake City, UT 84104, USA
www.dsiunderground.com

South America

DSI Chile Industrial Ltda.
Av. Isidora Goyenechea 3477
Las Condes, Santiago/Chile
www.dsi-chile.com

EMEA

DYWIDAG-Systems
International GmbH
4061 Pasching, Austria
www.dsi-tunneling.com

APAC (ASEAN)

DYWIDAG-Systems
International Pty. Ltd.
Bennetts Green, NSW 2290, Australia
www.dsiminingproducts.com/au

Change: Project & Legal Perspectives

Nigel Legge of Nigel Legge Associates and Iain Suttie of Berwin Leighton Paisner look at what constitutes change technically and how factors likely to give rise to major change can be anticipated, managed and mitigated. From a legal perspective it also reviews how engineering contracts categorise change and take account of its impact on cost and programme. This is the first of two articles on change.



Change on major underground infrastructure projects, like death and taxes in life, has an almost inevitable certainty.

Change in its broadest sense can result from many and varied causes: a client altering its project requirements, a contractor encountering unexpected physical conditions, the development of innovative technical solutions, or by alterations in the political, regulatory or funding environment. Any of these occurrences may impact project definition, cost and programming.

Change is an aspect of project risk, and the risk of change will be allocated to either the client or the contractor under the contract. The consequences of the client instructing change to a project scope is a risk that the client retains and is examined in some detail in the sections here dealing with contractual issues. Other risks, most obviously ground conditions, will be contingent on the nature of the project and will result in the contractor having an entitlement to additional time and money depending on how they are allocated under the contract.

Part two of this article addressing programme and quantum issues will consider methods that may be employed in practice to determine the amount of time or money allocated to a change event.

The project perspective

Technically, change may result from a wide range of factors that alter the scope, implementation or risk profile of a project, with consequential impacts on cost and programme. This important issue can be actively addressed throughout the project cycle in project definition and scope, planning and design, procurement and construction.

Project initiation & planning

An old military maxim states that 'Time spent in reconnaissance is never wasted'. Change is frequently associated with the construction phase, but the seeds of change events are often sown earlier in the project lifecycle.

Underground construction typically is associated with major infrastructure projects, where significant effort goes into the project definition and planning stages. Despite this, high level issues such as the reliability and accuracy of forecast data on traffic or passenger numbers, scope creep, stakeholder and political influence may still result in change.

It is now well established that industry best practice requires formal risk

management procedures to be actively applied on projects involving underground infrastructure. As a particular project risk, change should be explicitly included in the Risk Management Plan; this should be established at project initiation and continuously reviewed and updated throughout the project cycle. It is a client responsibility to ensure this process is in place at the early stages of the project. In the author's experience however there are still projects where this process is not followed, or is only applied later in the project cycle.

Some client organisations delegate risk management to the contractor, seeing their role as purely one of enforcing the contract. For the risk management process to function adequately, especially in relation to change, it is important that the full range of risks issues is considered and also that time and cost impacts are quantitatively evaluated.

An earlier article in this series (*T&T* September 2010, p46) on ground risk noted that this "remains one of the most significant issues for tunnelling and underground construction projects." The corollary of this is that inadequate investigation and characterisation of the ground is also one of the principal causes of change, both for underground and surface civil engineering projects. Despite much comment over years in the professional press, failure to involve geotechnical engineers early enough and inadequate ground investigation continue to impact and result in change on projects.

It is also important that ground parameters that provide the contractor with sufficient information to determine key issues—such as construction method, rate of excavation, abrasiveness, *in situ* stress, rockmass structure, permeability and water conditions—are adequately investigated.

For major underground projects, particularly in urban areas, early consultation with key stakeholders is important in order to minimise the likelihood of changes in later stages of the project. As has been demonstrated on the Hindhead and Crossrail projects in the UK, consultation with government agencies, local authorities, statutory undertakers and local residents requires significant time and resource allocation in the early stages of a project. The importance of this issue was demonstrated on an urban motorway project involving a tunnelled section when a pressure group representing some future commercial users, together with press coverage, resulted in the client reassessing

space-proofing requirements at a late stage of the project.

Design & programme development

At this stage of a project there are significant opportunities for unplanned change to be addressed and minimised.

Many projects go to tender with completed and checked detailed designs. Although this can be an effective way to minimise future change, construction efficiencies with cost savings may be proposed by tenderers requiring the design to be re-evaluated. Other projects go to tender on the basis of a partial design, typically 50 per cent, which is then completed either with the involvement of a 'preferred bidder' or post contract award.

Early contractor involvement (ECI) in the project development and design process has proved an effective way to minimise change. As well as providing valuable input and certainty concerning constructability and sequence issues, ECI can also provide benefits for public enquiries and managing external stakeholders. The Crossrail project will have a period of optimised contractor involvement after contract award in which the Engineer's design is reviewed and contractor proposed options are considered before the design is finalised.

The use of geotechnical baseline reports (GBR) is a significant development that provides a fixed contractual baseline for ground conditions. A key aspect is that the client organisation is responsible for both the factual site investigation data and its interpretation; encountered ground conditions outside defined ranges given in the GBR are compensation events under the NEC form.

Concerns have been raised by contractors, however, that the use of overly broad ranges for ground parameters may not adequately reflect actual conditions. It is also worth noting that an overly conservative interpretation of ground conditions can also result in change. On a recent major alpine tunnelling project the contractor's construction method and equipment were based on the anticipation of very poor ground. When the actual ground conditions encountered were better than predicted this represented a major change, with financial and programme implications for the client.

It is important that the issue of change is actively addressed through the risk management process during this stage. This will involve the development and

continuous review by all parties of design risk registers but, in relation to change, the process needs to be more widely applied. As required by the Joint Code of Practice², the client organisation is responsible for addressing all potential areas of risk associated with the development of the project and it is in the wider context that change hazards frequently exist.

Third party interfaces, particularly in urban areas, are an increasingly important issue for tunnelling projects and a potential source of change impact. The necessary approvals from affected parties such as Network Rail, LUL, various utilities, and building owners, typically require significant input at this stage necessitating the allocation of adequate design resources and allowances in the programme.

Construction and project organisation

The application of industry best practice in the pre-construction stages of a project will help minimise change. However, the significant complexity of modern underground infrastructure that frequently involves multiple parties, interfaces, disciplines, phases and contracts means that although change may be minimised it can rarely be avoided.

The use of partnering for major project delivery, with co-located task teams consisting of the client, designer and contractor, improves communication, design and construction efficiency, and is seen by many as having a positive impact on managing and mitigating project change.

Legal perspectives

As we have seen, 'change' can be defined very broadly in relation to engineering projects. In engineering contracts, however, change (or 'variation') is principally used to mean a change instructed by or on behalf of a client that alters the work the contractor is to carry out under the contract.

In basic terms, such change will result either in the delivery of an asset that is (to a greater or lesser extent) different in scope or nature to that otherwise required by the contract or in the contractor having to alter his method of working. The change itself may require additional work to be carried out or work to be omitted.

Change in this sense can be distinguished from 'changes' that arise out of "general" project risks, which may be owned by the client. For example, a contractor may, depending on the contractual risk allocation, have a claim for

time and money against the client if particularly adverse ground conditions are encountered or for additional payment if prices rise due to inflation.

Change in the specific contractual sense can also be distinguished from two other situations that people commonly consider to be 'change':

- Where a contractor carries out more work than he anticipated of a kind that is to be implied as necessarily ancillary to the construction of the required asset; and
- where a design is refined through a process of client approval under the contract.

In the first of these situations, the contractor may find, at least under a lump sum contract, that he has no entitlement to additional payment or time. A court would view the 'extra' work as being included in the contract price. (This is really an instance of a project risk having been allocated to the contractor; other risks allocated to the contractor would also result in no entitlement to additional time or money.) In sophisticated contracts for complex projects, the contractor may, however, have an entitlement to additional payment, depending on how the work to be carried out is specified and the contract prices are built up. Where there is such an entitlement it will, in principle, be a change in the sense we mean.

In the second situation, the process of design approval will not give rise to changes, unless the client misuses the process so as effectively to instruct the contractor to carry out work different in nature to that which he is required to carry out under the contract.

Change, procurement and pricing

The likelihood of change being required by a client is a type of project risk. The choice of contract for a project—and, more particularly, the choice of pricing mechanism—will in large part be determined by how project risk is to be allocated between the client and the contractor. The degree of control required by a client over design during the project lifecycle will also be a factor in determining the detail of the procurement route (e.g., the degree of responsibility the contractor takes on for design).

If major changes in scope are likely during the construction phase, it is generally thought to be more efficient for the procurement route to reflect this. For example, if the scope of the project is likely to change it will be better value for the client clearly to retain the associated risk and manage it through the contract change

mechanism, rather than seek to enter into, say, a lump sum contract that includes an inflated risk premium inserted against a relatively ill-defined scope.

In such cases it may be that a target contract or even a cost reimbursable contract is appropriate. Such contracts are, generally speaking, more likely to result in fair and transparent pricing of client instructed changes. They are consequently more tolerant of ongoing and relatively late changes in scope. In theory, all of this should promote a good client-contractor relationship, as the client will pay an appropriate price for work actually carried out. But much will depend on the details of the pricing mechanism, for example, how the contractor's ultimate fee against scope is calculated under a cost reimbursable contract.

In any case, experience shows that contractor claims for general loss and expense are more likely under contracts that transfer a high degree of risk to the contractor with only limited entitlement for additional payment under the change mechanism.

Contracts—the right to instruct changes

Engineering contracts invariably include a clause expressly permitting the client (or his representative) to instruct a change and stating how the cost of the change is to be determined. Without this, the client would have no right to require the contractor to implement a change and any request for a change would be subject to veto by the contractor. Even so, some standard form contracts give the contractor limited rights to object to change instructions (for example, the International Federation of Consulting Engineers contract (FIDIC) allows the contractor to object to an instruction because it will impact adversely on safety).

The client's right to instruct a change is not unconstrained. The general rule is that a change may only be instructed under a contract if the change is within the scope of the contract. This will be a matter of fact and degree. For example, a change instructing a contractor to construct a second tunnel under a contract to construct one would almost certainly be out of scope and the contractor would be entitled not to comply. But other cases may not be so clear-cut.

If a contractor does implement an out-of-scope change, he may be entitled to be paid a reasonable price for the additional work, without reference to the contract rates and prices.

An instruction to omit work may also be

outside the scope of a change clause. This is only likely to be the case where the omission is very considerable and would effectively result in the financial basis of the contract being rewritten unilaterally by the client. In such a case, the contractor would have a claim against the client for breach of contract.

The Institution of Chemical Engineers (IChemE) contract forms (including the international versions) attempt to provide certainty by stating that the contractor may object to a change instruction if it would result in the original contract price or target cost being increased or decreased by more than 25 per cent.

Change—standard forms

Standard form contracts not only permit the employer or his representative to instruct a change, but, in varying degrees, allow for or require the contractor to submit quotations for the cost and programme consequences.

For example, FIDIC's Silver Book for EPC (Engineering, Procurement, Construction)/Turnkey Projects and Gold Book for Design, Build and Operate Projects permit the employer or his representative to instruct a change, or request the contractor to submit a proposal prior to issue of an instruction. A contractor's proposal is to include proposed modifications to the programme and contract price.

Surprisingly, the FIDIC contracts provide little guidance on how the cost of a change is to be calculated. They simply provide that the amount of the adjustment shall include 'reasonable profit' and shall be agreed between the parties, failing which the employer or his representative is to make a 'fair determination in accordance with the contract'.

In itself, this may provide a contractor with relatively little assurance. As a matter of practice, it is likely that the parties will seek to incorporate additional detail into the contract setting out how the amount of a change - which may be very substantial - is to be calculated.

Similarly, IChemE allows the project manager to require quotations for potential variations. It also requires the project manager to give the contractor reasonable opportunity to comment on a proposed change prior to its instruction, unless delay in issuing the instruction would prejudice the works or the client.

Unlike FIDIC, IChemE requires the parties to include extensive detail in the contract schedules specifying how the cost of a change is to be calculated.

Under the lump sum Red Book, the cost is to be an amount that is reasonable in all the circumstances. However, the detailed calculation of the amount will be based on the heads of cost, rates, charges and fee for overheads and profit set out in schedule 18. If the project manager and contractor cannot agree the amount, it shall be such amount as the project manager decides.

IChemE's target cost Burgundy Book requires a change in the target to be 'determined as soon as is practicable' having regard to the schedules detailing cost elements, rates, charges and target cost mechanism.

A change will be grounds for an extension of time under both FIDIC and IChemE, requiring the contract programme to be updated.

The NEC3 ECC (Engineering & Construction Contract) does not contain a distinct set of clauses covering change. Instead, a project manager's instruction to change the works is a compensation event and is consequently dealt with under the compensation event procedure that covers all matters that may have time and cost consequences under NEC3. As such, change is subject to NEC3's early warning and risk register procedures.

In common with the NEC ethos, the compensation event procedure promotes a proactive 'real time' approach to dealing with such events. Time limits for response are set for each stage of the process, from notification of the event, through submission of the contractor's quotation for it (setting out his proposed cost and time changes) to the project manager's acceptance or rejection of the quotation.

NEC3 contains a number of default provisions that apply if the contractor or project manager does not adhere to the process. The programmatic nature of the compensation event mechanism distinguishes it from change procedures under FIDIC and IChemE.

Under NEC3, the amount of the adjustment to the price or target is, essentially, the change in the 'defined cost'. Simply, this means that the contractor is entitled to be paid the additional cost of carrying out a change plus a fee, albeit that the amount payable (under most NEC3 pricing options) will be calculated by reference to a relatively detailed schedule of cost components. In the case of target cost or cost reimbursable NEC3 contracts, the cost of additional sub-contracted work will be payable in full and will not be assessed under the schedule of cost components.

FIDIC, IChemE and NEC3 each allow for value engineering changes to be proposed by a contractor. The target under IChemE Burgundy Book and NEC3 Option C does not reduce if a proposal is accepted that reduces the cost of the works. This incentivises the contractor to make proposals, as he will share in any saving. It is less clear how value engineering may be encouraged commercially under a lump sum contract: the FIDIC contracts do not engage with this point.

Importantly, FIDIC, IChemE and NEC3 each contain a clause that limits the time in which the contractor may make claims in respect of 'change' in the broad sense. The rationale behind this is to promote active contract management and prevent possible claims being stockpiled for resolution at a later date, perhaps as part of a 'global' claim, when the parties' ability to analyse accurately the cost and programme implications will be reduced.

Conclusions

Change can be effectively managed and mitigated throughout the project cycle when industry best practices are applied. Of these, it is particularly important that change is adequately addressed in project risk management procedures and that the client organisation actively ensures this is applied.

Contractors and contract administrators should realise that not every event that impacts on the nature of and time for delivery of an asset will be a change that has contractual consequences.

The formal contractual change mechanism is relatively narrow and is focused on changes that reflect alterations in client requirements.

If a change event, in the broad sense, occurs that is not covered by the change mechanism, it will only lead to the contractor becoming entitled to additional time and money to the extent that it is covered by the general extension of time and loss and expense provisions in the contract. The scope for claims under these provisions may be limited, particularly under some forms of lump or EPC contract. ■

References

1. A Code of Practice for Risk Management of Tunnel Works. The International Tunnelling Insurance Group, 2006
2. The Joint Code of Practice for Risk Management of Tunnel Works in the UK, by the Association of British Insurers and the British Tunnelling Society, 2003

HYPERBARIC CHAMBERS / MEDICAL LOCKS & TOP QUALITY DISC CUTTERS FOR ALL TBMs AND CONDITIONS AVAILABLE

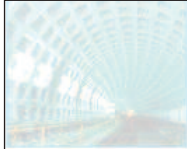


Design & Technic is global engineering conglomerate dedicated to provide top-notch engineering and construction services, technical know-how, customer oriented products and integrated solutions to the tunneling and mining industry.

Our extensive experience and precise expertise combined with close on-site consultation allow us to customize our engineering solution to cater to the unique challenge of every project. By integrating with the tunnelers from the start-up till the final breakthrough, we optimize your project execution that surpasses even the most daunting boring requirement in the world.

DESIGN & TECHNIC PTE LTD

Your Trusted agent for
 Condat , Cogemacoustic, Rockmore,
 RSB Formwork technology,
 Marti Conveyors etc
 61 Bukit Batok Crescent, #02-05 Heng Loong
 Building, Singapore 658078
 Tel : +65 6515 1970 Fax : +65 6515 1971
 www.d-t.sg & www.ef-asia.sg info@d-t.sg



Is nearby construction affecting your tunnel?



If so, you may need remote, continuous measurements to detect early signs of differential settlements before damage occurs.

The Geokon Model 46750C Precision Settlement Monitoring System will do the job, with a very high degree of accuracy and resolution, making it suitable for applications of a highly critical nature.

Model 46750C Precision Settlement Monitoring System

For

GEOKON The World Leader in Vibrating Wire Technology™

- ☎ 1-603-448-1562
- ✉ info@geokon.com
- 🌐 www.geokon.com

Sp SPECIALIST PLANT

VENTILATION SYSTEMS



Specialist Plant Associates supply robust temporary ventilation systems to suit any tunnelling or civil engineering application.

Specialist Plant Associates Ltd
 Phone: +44 (0)1234 781882
 Email: info@specialistplant.co.uk
 Web: www.specialistplant.co.uk



LEISTER

PLASTIC WELDING

Tunnel master builder



Proven, powerful and reliable. For all materials!

TWINNY T USB:

- Temperature and drive control
- Easy handling even overhead
- High welding speed
- USB data-recording

Leister Process Technologies
 Switzerland / www.leister.com

Editorial index for Volume 42 2010

Feature

A guide to education	June p32	Market - Going off the rails, Asia Pacific	Apr p26
Australia - Managing Melbourne's waste	June p27	Market - Growth potential, Australasia	June p23
Belgium - Old and new secure rail link	Sept p41	Market - High speed boom, Northern Europe	May p23
Change: project & legal perspectives	Dec p42	Market - Measuring up the Middle East	July p14
Chile - Growth in Chile	Nov p26	Market - North America's project potential	Aug p18
China - Kowloon's fight against flooding	Apr p29	Market - Spending heads south, Latin America	Nov p18
China - Hong Kong flood relief	Apr p35	Market - Subcontinent weathers the storms, India	Dec p16
Denmark - Danish dash, metro and undersea link to Germany plans	May p32	Market - Transportation salvation, Southern Europe	Oct p14
Egypt - Excavating Cairo's Metro Line 3	July p23	Mexico - A master plan for metro expansion	Nov p21
Germany - Bauma 2010	Mar p16	Mexico - Mexico's urban challenge	Mar p28
Germany - What to spot at Bauma	Mar p18	Netherlands - LEDs leading lighting	Aug p36
Gift of the gab	June p37	Norway - Atlantic Ocean tunnels in Norway	Nov p46
Great Britain - 20 years of steel fibre concrete lined tunnels in UK	Sept p28	Panama - Panama power, EPB TBMs to dig headrace tunnels	Nov p28
Great Britain - Belfast Sewers Project - part 2	Feb p42	Russia - Beneath the barrier, St Petersburg Flood Barrier	May p24
Great Britain - Brighton's sewer upgrade	Sept p23	Spain - Heading for Basque airport, Bilbao's metro Line 3	Oct p25
Great Britain - Catch up on Crossrail	Sept p18	Spain - Segment fibre reinforcement in Barcelona	July p41
Great Britain - Digging under The Dorchester, London hotel service link tunnel	Sept p31	Sweden - Hallandsas first drive approaches end	May p28
Great Britain - Monitoring Stratford, careful monitoring of surface movement under railways for West Ham Flood Alleviation Scheme	Nov p38	Switzerland - Guidance at Gotthard, navigation of TBMs	Nov p41
Great Britain - Slog on the Tyne	Mar p24	Switzerland - Securing the Gotthard Road Tunnel against salts	May p47
Great Britain - West Ham Flood Alleviation Scheme	July p55	Switzerland - The Gotthard Base Tunnel and Sedrun	June p49
India - Capital metro expansion	Dec p19	Technical - Advantages of pre-injection grouting	Oct p49
India - Long bores in remote India, Andhra Pradesh tests TBM limits	May p36	Technical - Breath of fresh air	Dec p31
India - Monitoring Rohtang	Dec p22	Technical - Choosing the right fibre for the right use, reinforcing concrete	July p35
India - Pir Panjal: NATM in the Himalayas	Feb p23	Technical - Clarifying the fog of fibres,	July p28
Iran - TBM performance prediction in Iran	May p51	Technical - Design and construction of deep shafts	May p56
Italy - Breaking new ground in Rome	July p50	Technical - Drill and blast developments	Feb p16
Italy - Livorno landfall, project to import gas	Oct p31	Technical - Examining pipe bursting safety	Feb p39
Italy - Two-component backfill grouting on Rome's Line C	July p45	Technical - Excavating near existing CI linings, Part 1, predicting the response of existing linings	Mar p32
Market - Britain's got tunnels	Sept p16	Technical - Excavating near existing CI linings - Part 2, predicting the response of existing linings	Apr p48
		Technical - Finesse in tough environments	Nov p33

Technical - Flexible friends at the face, current means and trends of excavation	Apr p43
Technical - High pressure mist for fire suppression	Oct p43
Technical - Jet fans: Removing non-conservatism from CFD modelling	Dec p33
Technical - Managing ground risk	Sept p46
Technical - Meeting shotcrete specifications	Mar p41
Technical - 'No-Dig' techniques continue to advance	Feb p32
Technical - Saving sustainably - polymeric binders for tunnel support	Mar p44
Technical - Saving the tunnel customer, safety developments	Oct p36
Technical - Stabilising ground conditions around tunnelling routes	Sept p37
Technical - Still thrusting forward, the state of pipe jacking	Aug p40
Technical - The benevolent 'big brother', tunnel monitoring and control developments	June p38
Technical - Thin barrier integrity - the easy way?, sprayed membrane developments	May p41
Technical - Trademarking the NTNU/SINTEF drillability test indices	June p44
Technical - Winds of change for tunnels environment	Dec p29
There must be a better way, ground conditions and risk allocation	Dec p37
Tunconstruct reports, 'Technology Innovation in Underground Construction' book review	Aug p42
Turkey - A city steeped in history breaks new ground, Marmaray Project	Oct p16
Turkey - A sinking success in Istanbul, Marmaray Project	Oct p20
UAE - Abu Dhabi's super sewer	July p17
UAE - Feeling the heat, Shis Tunnel	Feb p19
UK's ability to muster resources, BTS Young Members debate	Mar p36
USA - Home run for river clean up, Oregon sewer nears completion	Aug p21
USA - Never so bored in NY, TBMs aid cavern construction	Aug p31
USA - So San Francisco doesn't go thirsty	Aug p25
Vietnam - Planning a metro in Ho Chi Minh City	Apr p39

Author

Auld, A	May p56
Awale, P	Dec p22
Barbanti, M	July p50
Bedi, A	Mar p32, Apr p48
Berge, B	July p41
Bezler, J	Mar p44
Boscaro, A	July p45
Bruland, A	June p44
Buonfiglioli, M	Dec p33
Chemie, W	Mar p44, May p47
Clarke, I	Feb p32, Sept p37
Comins, J	Sept p31
Conacher, A	Dec p14, Dec p16
Cowan, I	Dec p33
Dahl, F	June p44
Duncan, I	Dec p37
Essex, R	Dec p37
Greeman, A	July p23
Greenhalgh, J	Sept p28
Gregory, F	Mar p44
Gritt, E	Feb p19, Mar p24, Apr 39
Groev, E	June p44, Nov p46
Gulino, G	July p50
Harrison, S	Nov p38
Hindmarsh, A	Dec p37
Hognestad, H	Oct p49
Holter, K	Oct p49
Ibell, R	June p49
Jones, M	Feb p16, Mar p41, Apr p43, May p28, June p3, June p38, July p28, Aug p3, Aug p21, Aug p25, Aug p40, Aug p42, Sept p41, Oct p25, Oct p36, Nov p33, Dec p29, Dec p23

Kemmann, C	Mar p16
Knights, M	Mar p15
Legge, N	Sept p46, Dec p42
Messing, M	Nov p41
Mole, K	Apr p18, May p23, June p15, Aug p14, Sept p23
Mules, M	Sept p31
dal Negro, E	July p45
Nelson, P	June p17
Nielsen, J	Feb p39
Nilsen, B	June p44
Oraee, K	May p51
Paolini, T	July p50
Patterson, R	Dec p37
Prinzl, F	Feb p23
Ravn, S	Dec p33
Reynolds, P	May p15, May p32, Aug p31, Oct p31, Nov p26, Nov p28
Redfern, B	June p23, June p27, July p14, July p17, Sept p18
de Rivaz, B	July p35
Robinson, N	June p32, Aug p18, Aug p36, Sept p16, Oct p14, Oct p16, Oct p20, Nov p16, Nov p18, Nov p21
Ronicle, P	Feb p42
Salak, P	Sept p31
Salhi, B	May p51
Sarkissian, A	May p51
Schulkins, R	July p45
Spiby, K	July p55
Suttie, I	Sept p46, Dec p42
Tarada, F	Dec p31
Vuolle, P	Oct p43
Wallis, S	Mar p36
Whitaker, G	May p24
Willis, D	Mar p28, May p36
Young, J	Jan p3, Feb p5, Mar p5, Apr p3, Apr p26, Apr p29, Apr p35, May p3, June p37, July p3, July p12, Sept p3, Oct p3, Oct p12, Nov p3, Dec p3, Dec p19

Comment

Comment	Jan p3
---------	--------

The China syndrome	Feb p5
From the horse's mouth	Mar p5
Buried legacy	Mar p15
Show me the money	Apr p3
It's all in the timing	May p3
Why the same old, same old	June p3
Back to school	June p17
Price of the space race	July p3
Safety concern or sensation	Aug p3
Finding hope for Crossrail	Sept p3
Will we, won't we?	Oct p3
Record breakthrough	Nov p3
Capitalising on competition	Dec p3

News in depth

Austria - Largest contractor lands largest contract	Dec p14
Canada - City at loggerheads over proposed tunnel	Sept p14
Chile - Raiseborer tries to free trapped miners	Oct p12
Czech Rep. - Questions asked as Blanka Tunnel collapses for third time	Aug p14
Great Britain - Off the beaten tracks, Crossrail	Apr p18
Great Britain - HS2 tunnels	May p15
Great Britain - Tube extension rushes ahead	July p12
India - Filling in the gap, Malad tunnel repairs	June p15
USA - Calling off ARC	Nov p16

Supplements

T&T Asia: Volume 1	June
T&T Asia: Volume 2	Oct
T&T Bauma, Munich	Apr
T&T Gotthard	Nov
T&T Heavy Lift	Dec
T&T Hedinsfjordur	Dec
T&T North America: Volume 36	Mar
T&T North America: Volume 37	May
T&T North America: Volume 38	Sept
T&T North America: Volume 39	Dec
T&T World Tunnel Congress	May

Product marketplace

To advertise on this page call Tom Willard on: +44 (0)20 7936 6843 or email twillard@tunnelsonline.info



NEW IMPROVED VENTILATION SYSTEM FROM GIA INDUSTRIES FOR MINING AND CONSTRUCTION TUNNELS

A new generation of Swedvent underground ventilation fans and ducting system from GIA Industries offers improved noise emissions

A new generation of Swedvent ventilation fans and ducting for tunnel construction is introduced by Sweden's GIA Industries featuring reduced noise levels.

Improved silencer design offers noise reductions of at least 3 dB(A) for the full range of fan motors rated between 10 – 500kW to meet 75 – 85 dB(A) at 7m. The improved sound damping has been achieved with a specially designed silencer filled with processed mineral wool to reduce high frequency sounds.

The ventilation system features advanced impeller design incorporating a large hub, short blades and, accurately measured spacing between the blades to give the fan an enhanced ability to counteract high pressure systems.

The dynamically balanced impeller rotates in purpose - designed guide vanes to eliminate turbulence.

Individually adjustable aluminium blades allow the same fan to be used for a number of different tunnel conditions by adjusting the blade angle.

GIA INDUSTRIES

T: +46 24079700

E: info@gia.se

W: www.gia.se



WR 89 NewGeneration TAIL SEAL GREASE

WR89 NewGeneration is continuously pumped during the progress of the machine. Injected between the rows of brushes, it allows a perfect sealing against water, slurry and grout, insuring the sealing of the TBM while tunneling.

The innovating formulation of WR 89 NewGeneration provides improved performance while keeping in mind a sustainable development:

- More eco-friendly components anticipating future specifications
- Biodegradability keeping pace with OECD regulations
- Higher level of safety thanks to its fire resistance properties
- Reduction by at least 10% of the consumption with the help of new anti-friction additives. This reduction has been proved on several jobsites.
- Reduction of the carried quantities
- Perfect compatibility with WR 89 and the emergency product: Condat Emergency Seal.

WR 90, used for the first packing of the brushes, also took advantage of the same evolution in a sustainable development way and is replaced by the WR90 NewGeneration.

CONDAT S.A.

T: +33- 478 07 38 45

E: tmsi@condat.fr

W: www.condat.fr



INDUSTRIAL TELEPHONE

HONGKONG KOON TECHNOLOGY LTD is a leader in the research and development, manufacture and sales of Industrial series telephone products.

We would like to cooperate with you either OEM or ODM business for a very long time.

Our Major products are Special Industrial telephone: Waterproof telephone, Loud speaker weatherproof telephone, Bank telephone, Tunnel emergency telephone, Elevator telephone, Prison telephone etc. Applicable for Subway, Railway, Highway call box, Tunnel, Power plant, Petrochemicals factory, Mining, Dockside, iron & steel factory.

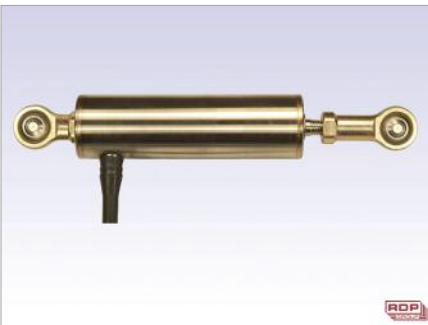
The above models are CE/FCC/IP66 approved. They are patented design with aluminum body, anti-damp, corrosion-resistant, Performs in environment: -30-60°outdoor. Memory keypad, Magnetic reedhook-switch, Line powered, Anti-knock handset and cable. All the products are waterproof, Vandal resistant, Corrosive-resistant aluminium construction. Memory keypad for speed-dial, Metal keypad, Anti-knock handset with armoured cable... That's why we can keep friendly Co-operation with SIMENS, ALCATEL, CISCO, AVAYA, TADIRAN, HUAWAI, TTIC, Schlumberger & HARRIS for over 5-10 years. Our customers: UK Railway, Italy railway, Singapore railway, Hong Kong railway and Taiwan railway etc. They are very happy with our products for years.

HONGKONG KOON TECHNOLOGY LTD

T: +8675529950418

E: koon03@vip.163.com

W: www.koontech.com



RDP OFFERS COST EFFECTIVE MEANS OF MONITORING DEFLECTIONS IN TUNNELS

Movement and deflection in tunnels can be effectively monitored using a range of water-resistant LVDTs developed by measurement specialists RDP Electronics Ltd.

Concrete and steel lined, or hewn rock, tunnels can be subject to movement and deflections due to the overlying rock strata. In areas of geological or seismic activity there may be a greater need to monitor movements, which may foretell damage or even collapse of the structure. Transducers to provide accurate response in what is typically a wet and dirty environment usually calling for long cable runs can be met by special water-resistant RDP LVDTs with 4 – 20mA analogue output. Pinned to the tunnel walls an installation may involve tens, or even hundreds of LVDTs with cable runs of 100m or more which is made possible by using these analogue devices.

Further information and guidance concerning transducers for use in tunnel wall monitoring applications can be obtained from the RDP engineering support team on 01902 457512.

RDP ELECTRONICS LTD

T: +44 (0)1902 457512

E: sales@rdpe.com

W: www.rdpe.com



VOLVO LAUNCHES ITS 20 TONNE EXCAVATOR STAR AT BAUMA CHINA

EC200B Prime excavator

The EC200B Prime excavator is a brand new machine, designed for general construction in segments like utility, building and road construction in the Chinese market. It is a custom-made Volvo solution for Chinese customers in the earth moving sector, particularly those working in urban areas. The new machine is an excellent tool to meet their demand on high productivity, fuel efficiency and optimum ownership cost.

Fitted with a high performance, low emission Volvo engine, the new model can develop peak torques at low rpm. The new machine features cutting edge load-sensing hydraulics, excellent attachment geometry and state-of-the-art electronics to ensure productivity at the lowest cost per ton. Combined with Volvo's renowned fuel efficiency, the new EC200B Prime offers customers 'more bangs for their buck'.

VOLVO

T: + 32 2 482 5021

W: www.volvoce.com/global

W: www.volvoce.com/press

Recruitment directory

To advertise on this page call Tom Willard on: +44 (0)20 7936 6843 or email twillard@tunnelsonline.info

Global Tunnelling Experts. Bringing the best together.



Global Tunnelling Experts is your teamwork partner for the best human resource solutions on your tunnel construction site. We supply personnel for all jobs throughout all the construction phases – including operational job profiles for all aspects of mechanized tunnelling operations and the equipment they involve. **Choose the right experts and contact us now.**

Global Tunnelling Experts
+31 (0) 10 266 94 44
clients@global-tunnelling-experts.com
www.global-tunnelling-experts.com
The Netherlands | Great Britain | Cyprus



Hunter Personnel International Recruitment

Specialists in Tunnelling, Civils and Construction Recruitment

TBM Site Test Manager

Ref: BN505 – Middle East

Tunnel Design Manager

Ref: PN4336 – Australia

Tunnel Construction Manager

Ref: PN4335 – South East, UK

Tunnel Design Engineer

Ref: PN4334 – South East, UK

Senior Civil Engineer

Ref: PN4321 – York, UK

Construction Manager

Ref: PN4318 – Hong Kong

Please send CVs to David Kellett

tt@hunterpersonnel.com

T: +44 (0) 1202 298322

www.hunterpersonnel.com



A unique opportunity exists to register with **Tunnel Force** and join tunnelling projects located in Australia and Asia.

We are currently seeking expressions of interest from qualified and/or experienced:

- Slurry TBM operators for Singapore
- Project Managers
- Design Engineers
- Shift Engineers
- Superintendent - General, Tunnel, Mechanical and Electrical
- Tradespeople - Fitters, Electricians and Boilermakers
- Technicians - Hydraulic and PLC
- Operators - TBM (Hard Rock, EPB), Pipe-jacking and Road Headers
- General Shift Supervisors & Tunnel Builders



Register your interest by emailing your CV to jobs@tunnelforce.com.au



STRONG HERITAGE | STRONG FUTURE
RHONDDA CYNON TAF
TREFTAETH GADARN | DYFODOL SICR

EXPRESSION OF INTEREST TO TENDER FOR GROUND STABILISATION WORKS

Rhondda Cynon Taf County Borough Council seeks expressions of interest from suitably qualified and experienced contractors for undertaking ground stabilisation works at Albion Lower Tip, Cilfynydd, Pontypridd.

The proposed scheme will involve the installation of directional drilled drains and wells in natural superficial deposits beneath colliery shale, 5 to 12m deep and other drainage measures, on a south west facing hillside, to the north east of Cilfynydd. The works are required for the long term stability of the tip.

The proposed works is envisaged not to take more than 12 months with a maximum value of £3,500,000. The principal contractor will be required to employ the services of a specialist contractor for the directional drilling aspect. The principal contractor will assist Rhondda Cynon Taff County Borough Council with developing the detailed design under a NEC3 Professional Service Contract and agreeing the cost for the works under an NEC3 Option B contract. Should the contract sum be of interest then the project will proceed to construction.

Contractors wishing to express an interest in tendering for this contract should write to Rhondda Cynon Taf County Borough Council marked for the attention of:-

Mr Andrew Stone
Land Reclamation & Engineering Manager
Rhondda Cynon Taf County Borough Council
Sardis House
Sardis Road
Pontypridd
Rhondda Cynon Taf
CF37 1DU

Expressions of Interest to tender should arrive no later than 20th December 2010

Business directory

To advertise on these pages call Tom Willard on: +44 (0)20 7936 6843 or email twillard@tunnelsonline.info

CHEMICALS

On parle
EPB
ici....*



(SO FOR A QUICK CHAT ABOUT TBM SPOIL CONDITIONING, CALL MORRISON MUD!)

*
Morrison Mud division of Mudtech Ltd
+44 (0) 1929 551245
sales@mudtech.co.uk



The Chemical Company



Expanding Horizons Underground

www.meyco.basf.com

CUTTER TOOLS



T.B.M. CUTTERS Ltd.

DESIGN AND MANUFACTURE OF TBM CUTTING TOOLS AND WEARPARTS
CUTTER HEADS MANUFACTURED & MODIFIED

TEL. +44 (0) 1430 427954 FAX. +44 (0) 1430 427955
EMAIL. office@tbmcutters.com www.tbmcutters.com

CUTTER TOOLS



LEADERS IN ROLLER CUTTERS AND TOOLS


MANUFACTURED FOR ALL TYPES OF TUNNEL BORING MACHINES, MICROTUNNELING UNITS AND VERTICAL DRILLING EQUIPMENT OF ALL MAKES, EITHER STANDARD OR CUSTOM DESIGN

PH. +39 0534 32511 FAX +39 0534 32501
sales@palmierirocktools.com www.palmierigroup.com

Agents wanted in selected countries. Please apply to: a.tasselli@palmierirocktools.com

ENGINEERING CONSULTANTS

Tunnel, Caisson & Cavern



BABENDERDE ENGINEERS

Worldwide engineering service with experience in all types of geology and construction techniques

- ◆ Design Assistance
- ◆ Consulting
- ◆ Construction Management
- ◆ Technical Assistance

Germany, USA, Brazil

www.babeng.com

TONY RIDLEY HYPERBARIC ASSOCIATES LTD

Consultancy, Expertise and Personnel

Specialist Tunnelling Services

Compressed Air - TBM Intervention - Safety - Rescue - Occupational Health

Tel +44 (0) 1508 538 838
Fax +44 (0) 1508 538 938
Email info@hyperbaric-tunnelling.com
www.hyperbaric-tunnelling.com

ENGINEERING CONSULTANTS



Alan Auld GROUP LTD

TUNNEL AND SHAFT DESIGN SPECIALISTS

Telephone +44 (0) 1302 329911
Fax +44 (0) 1302 329922
Email mail@alanauld.co.uk
Website www.alanauld.co.uk



BELLOLI SA CH-6537 GRONO

The specialist for tunnelling equipment

www.belloli.ch

EQUIPMENT

EQUIPMENT FOR

M I N I
S I



GIA w

Sp SPECIALIST PLANT

TUNNELLING EQUIPMENT HIRE & SUPPLY

Specialist Plant Associates Ltd

Agents for **CIFA**

Tel: +44 (0) 1234 781 882
Email: info@specialistplant.co.uk
www.specialistplant.co.uk


EQUIPMENT

A.S.T. Bochum

Armaturen- Schlauch- und Tunneltechnik

Special fittings, hoses and tunnelling equipment for:

- Erection plant
- Machine requirements
- Microtunneling
- Drill&Blast tunneling
- Air pressure supply
- Concrete formwork engineering
- Special civil engineering
- Shot concrete engineering
- TBM tunneling
- Freezing engineering
- Wearing protection
- Draining



Tel. +49 (0)234 / 5 99 63 10 - Fax +49 (0)234 / 5 99 63 20
www.astbochum.de

The one-stop source for the tunnelling industry.



It's only a mouse click from here!

tunneltrade.com
Your tunnel, internet portal



Custom design and manufacture of tunnel laser

Visit our website for datasheets and application notes

www.vidalaser.com

FABRICATION

F TRANSFORGE UK LTD

Tunnel Steelwork Specialists

Cable & Pipe Brackets and Walkways
Sleepers and Accessories

+ 44 (0) 1572 787 504
info@transforge.co.uk

GROUND CONTROL

DYWIDAG-SYSTEMS INTERNATIONAL **DSI**

ALWAG SYSTEMS

GROUND CONTROL SOLUTIONS

DSI UNDERGROUND SYSTEMS INC.

www.dsi-tunneling.com

MICROTUNNELLING

WHEN THE GOING GETS TOUGH...
...Iseki comes smiling through!

Microtunnelling equipment - hire or sale



ISEKI MICROTUNNELLING

Iseki Microtunnelling Wellingborough UK
+44(0)1234 781166 www.isekimicro.com

PIPES & COUPLINGS

SVEBRA

LIGHTWEIGHT PIPING

Quick Coupling Pipes And Fittings

Strandvägen 25 | 686 30 Sunne, Sweden | T: + 46 565 689410 | F: + 46 565 711215

www.svebra.se

Business directory

PIPES & COUPLINGS



Quick connected steel pipe system

P.O. Box 550
SE-631 07 ESKILSTUNA, SWEDEN
Tel: +46 16 16 65 00
Fax: +46 16 12 26 34

RAIL & ROLLING STOCK



World Leading
Clayton Locomotives & Haulage Solutions...

...for Mining, Tunnelling & Surface Transport



Clayton Equipment Ltd
www.claytonequipment.co.uk Tel: +44 (0) 870 112 9191



TUNNELLING & MINING EQUIPMENT



Valente S.p.A Phone: +390293799212
Via Don Minzoni, 06 Fax: +390293799349
20020 Lainate (MI) ITALY
www.valente.it info@valente.it

RAIL & ROLLING STOCK



Your partner for special solutions
in the tunnelling sector.

Phone: +49 (351) 42 34-0
Fax: +49 (351) 42 34-103
E-Mail: info@msd-dresden.de
www.msd-dresden.de

ROCKBOLTING



www.ct-bolt.com

SEGMENT FITTINGS



PLASTIC COMPONENTS FOR SEGMENT CONNECTION
BUILDING AND GROUTING SYSTEMS

WWW.TTCLTD.ORG
+44(0)1455 234401

SURVEYING & MONITORING



www.vmt-gmbh.de



tunnel atmosphere monitors

t : +44 (0) 1629 814 351
f : +44 (0) 8700 566 307
e : sales@codel.co.uk

www.codel.co.uk

TUNNELLING SUPPLIES



Robit
ROCKTOOLS

Reliable tunnelling tools from Finland

Please see our web pages for more details:
tel. +358 3 3140 3400 • **www.robit.fi**

TUNNELLING SUPPLIES

EPDM GASKETS		BULLFLEX
PLASTIC SEGMENT FITTINGS		SEALING STRIPS
FOAMS & POLYMERS		SECONDARY SEALS
HYDROPHYLIC RUBBER		TBM LAUNCH SEALS
BOLTS		LUBRICANTS
PACKERS		ROLLING STOCK
LIFTING EQUIPMENT		

+44 (0) 1424 854112
info@tunnellingaccessories.co.uk
www.tunnellingaccessories.co.uk

VENTILATION

SCHAUENBURG
TUNNEL-VENTILATION GMBH

Flexible Ventilation Ducting
www.tunnel-ventilation.de
Phone: +49 208 8827610
Fax: +49 208 8827615

VENTILATION DUCTING

VEE VENTILATION ENGINEERING COMPANY (P) LIMITED

Tel : (+91-33) 22263882 / 22271303
Fax : (+91-33) 22262585
Email: ventduct@vsnl.com
WWW.DUCTSANDHOSES.COM

WATERPROOFING

CAVIDRAIN
Waterproofing & Drainage for Tunnel Walls & Invert

T: +44 (0) 1484 852250 | F: +44 (0) 1484 354825 | E: export@abg ltd.com
www.abg ltd.com

WHEELS

BRAUER

Brauer Limited.
Dawson Road, Mount Farm, Milton Keynes, MK1 1JP

t: +44 (0)1908 374022 f: +44 (0)1908 641628
e: sales@brauer.co.uk w: www.brauer.co.uk

BTS corporate members

To advertise on these pages call Tom Willard on: +44 (0)20 7936 6843 or email twillard@tunnelsonline.info



This is not the full list of British Tunnelling Society Corporate Members | To see a full list of all members visit: www.britishtunnelling.org.uk



ACS
inner strength in construction
Specialist Structural Fabricators
+44 (0)844 850 0860
www.acsstainless.com
Stainless Steel Titanium Mild Steel

Applied Industrial Systems Ltd



Tunnel Control & SCADA
www.tunnelautomation.com

ARUP

T: +44 (0)20 7636 1531
E: london@arup.com
W: www.arup.com



Proven specialists in addressing skilled labour shortages

www.atlancorimec.com

Special Fabrications in Stainless Steel



Tel: +44 (0) 114 275 5224
www.ancon.co.uk/fabrications



WWW.BARHALE.CO.UK
+ 44 (0)844 736 0050



+44 (0)20 7651 7887
www.bechtel.com

Balfour Beatty
Civil Engineering

+44 (0)1737 785 000
enquiries@bbcel.co.uk
www.bbcel.co.uk



The Chemical Company



Expanding Horizons Underground
www.meyco.basf.com



www.costain.com

Danny Sullivan & Sons Ltd
BUILDING CIVIL ENGINEERING

enquiries@dannysullivan.co.uk
+44 (0)20 8961 1900
www.dannysullivan.co.uk



www.deneef.com



www.dr-sauer.com



DONALDSON ASSOCIATES
www.donaldsonassociates.com



www.flag-soprema.co.uk



Gall Zeidler CONSULTANTS, LLC
GEOTECHNICS | TUNNEL DESIGN | ENGINEERING
www.gzconsultants.com

HUNSLET
ENGINE COMPANY
Locomotive Suppliers

T: +44 (0)113 2774007
F: +44 (0)113 2773005
E: info@hunsletengine.com



HERRENKNECHT
Tunnelling Systems
www.herrenknecht.com

Hunter Personnel
International Recruitment

Specialists in Tunnelling, Civils and Construction Recruitment

www.hunterpersonnel.com



Joseph Gallagher Ltd
Tel: +44 (0)1375 672070
Fax: +44 (0)1375 672073
Email: headoffice@josephgallagher.co.uk

BTS corporate members



If you wish to become a British Tunnelling Society Corporate Member please email: bts@britishtunnelling.org.uk

J K GUEST
**CIVIL ENGINEERING
 TUNNELLING
 PILING
 UTILITY MAPPING**
www.jkguest.co.uk
 +44 (0)1257 425742
 +44 (0)1257 426042

lba
**LONDON BRIDGE
 ASSOCIATES LTD.**
www.lbassoc.co.uk
*Delivering value across the
 construction cycle.*

LAING O'ROURKE
www.laingorourke.com
 01322 296200

Mott MacDonald
 Mark Leggett
 T: +44 (0)20 8774 2758
 E: mark.leggett@mottmac.com
www.tunnels.mottmac.com

MINOVA
www.minovainternational.com

**MORGAN
 SINDALL**
 T: 01788 534500
morgansindall.com

MURPHY
MURPHY GROUP
info@murphygroup.co.uk
www.murphygroup.co.uk
 +44 (0)20 7267 4366

**Natural
 Cement**
www.naturalcement.co.uk

**PB PARSONS
 BRINCKERHOFF**
 44-(0) 1483-528400
enquiries@pbworld.com
www.pbworld.co.uk

SHOTCRETE
 +44 (0) 1580 714747
enquiries@shotcrete.co.uk
www.shotcrete.co.uk

SES
 SPECIALIST ENGINEERING SERVICES LTD
 Wright Business Park, Carr Hill, DONCASTER DN4 8DE
 T: 01302 733681
 F: 01302 733693
 W: www.ses-holdings.com

Tam
 Global Construction Chemicals
normet
 FOR TOUGH JOBS
www.taminternational.com
www.normet.fi

TERRA
 SOLUTIONS LIMITED
 Microtunnelling, pipejacking and
 shaft construction specialists
Terra Solutions Ltd
 Tel: +44 (0) 28 30269848
 Fax: +44 (0) 28 30269860
www.terrasolutions.co.uk

Piping. Systems. Solutions.
victaulic®
www.victaulic.com

VVB
 Engineering Services Ltd
VVB Engineering Services Ltd
 Tel +44 (0)1268 711845
 Fax +44 (0)1268 711846
www.vvb-eng.com

VINCI CONSTRUCTION | GRANDS PROJETS
 Tunnelling works:
 world class innovative solutions
www.vinci-construction-projects.com/british-isles

**WARD & BURKE
 CONSTRUCTION LIMITED**
 Microtunnelling
 Auger Boring
 Caisson Shafts
 Structural Engineering
www.wardandburke.ie

This is not the full list of British Tunnelling Society Corporate Members
 To see a full list of all members visit: www.britishtunnelling.org.uk
 If you wish to become a British Tunnelling Society Corporate Member
 please email: bts@britishtunnelling.org.uk





tunnels
& tunnelling
INTERNATIONAL

RESERVE YOUR COPY OF
TUNNELS & TUNNELLING
INTERNATIONAL
simply visit
www.tunnelsonline.info

**SUBSCRIBE
TODAY!**

With over 40 years experience Tunnels & Tunnelling International is the world's leading publication in the tunnelling industry.

dates & events

17 - 19 JANUARY 2011

Infrastructure Middle East 2011 - GCC States Prepare for the Future

New huge and fast growing metropolitan areas are mushrooming in Saudi Arabia, Bahrain, United Arab Emirates, etc. But the infrastructure is not always able to keep pace. 'Infrastructure Middle East' in January 2010 that was of such success that it has been enlarged into 'Infrastructure Middle East 2011' with three conferences: underground Infrastructure, water and waste water, traffic and transportation.
Email: fandrigh@eitep.de
Tel.: +49 511 90992-22

25 - 27 JANUARY 2011

Underground Construction Technology International Conference & Exhibition, Houston, Texas

Trade event for underground utility construction focused exclusively on installation and rehabilitation of the underground infrastructure.
Tel: +1-301-694-5243; Fax: 1-301-694-5124;
Web: www.uctonline.com; UCT P.O. Box 941669, Houston, TX 77094-8669

1 - 3 MARCH 2011

International conference and exhibition on tunnelling and trenchless technology, Selangor, Malaysia

The 2011 conference organised by the Tunnelling & Underground Space Technical Division (TUSTD) at The Institution of Engineers, Malaysia (IEM), will focus on tunnelling in South East Asia, future challenges and management of safety and risk. Tel: +(603) 7968-4001 / 4002; Fax: +(603) 7957-7678; Email: Tunnel2011@iem.org.my
Website: www.iem.org.my

8 - 10 MARCH 2011

The 14th Australasian Tunnelling Conference

Organisers are aiming for a meaningful conference to mark the start of the Second Decade of the 21st Century, setting a standard for the 2014 ITS Conference in Sydney. An extensive array of topics are to be covered. Contact: Belinda Martin, the AusIMM. Tel: +61 3 9658 6125
Email: bmartin@ausimm.com.au

13 - 16 MARCH, 2011

2nd Annual Tunnels & Underground Construction Summit, Abu Dhabi

Building on the success of the 1st Annual Tunnels & Underground Construction Middle East summit, which was held in May, in Abu Dhabi, IQPC is delighted to announce the dates for its 2nd annual event. Featuring:
* A transport projects focus day
* More case studies and scientific papers with over 25 leading speakers
* More participation from Saudi Arabia, Qatar and Egypt
Tel: +971 4 364 2975
Email: enquiry@iqpc.ae

7 - 9 APRIL 2011

Underground Space - 1st Scientific Symposium on Tunnels and Underground Structures in South-East Europe

The intention of this symposium is to proliferate the knowledge of tunnelling and use of underground space which is already the state-of-the-art in other parts of the world. The

topics focus on all aspects of durability of structures from conceptual stage to design, construction, operation and maintenance phases. Contact: Symposium Secretariat manager, Ms. Tanja Rabar
Tel: 00385-51-322-854
Email: tanja.rabar@hubitg.com

21 - 26 MAY, 2011

WTC 2011 Helsinki - Underground spaces in the service of a sustainable society

The Finnish Tunnelling Association awaits you in Helsinki. A boom in tunnelling is currently underway in Finland. In this exciting environment WTC 2011 has been organised. General subtopics to include: planning the usage of subterranean spaces, municipal services, operational technologies, traffic and logistics, geologic disposal of nuclear waste, renewable energy, project management.
Website: www.wtc11.org
Booking / accommodation enquiries:
Tel: +358-9-5607500 Email: wtc11@congress.fi

29 - 30 JUNE 2011

Underground Construction Conference and Exhibition, London

The eyes of the global tunnelling industry are swivelling towards the UK with some of the world's largest underground construction projects getting underway. Event includes: technical and design developments in underground construction, tunnel operation and maintenance, sustainable development and minimising the impact of underground works, a world wide tunnelling perspective, UK projects - today and the future, ground investigation, treatment and monitoring.
Tel: +44 (0) 207 973 6695
Email: g.stringer@hgluk.com
Website: 2011.tunnellingshow.com/

12 - 16 SEPTEMBER 2011

6th International Symposium on Sprayed Concrete, Tromsø, Norway

Main themes will be design, construction and durability of wet-mix sprayed concrete in underground structures. The Norwegian Concrete Association is currently revising the Publication No. 7, Sprayed Concrete for Rock Support. This will be debated during the symposium. Contact: Siri Engen Email: siri.engen@tekna.no Website: www.sprayedconcrete.no

26 - 27 OCTOBER 2011

XI International Conference Underground Infrastructure of Urban Areas, Wroclaw, Poland

A forum to develop an exchange of experiences and provoke a discussion on the topics related to building of tunnels and underground infrastructure in cities.
Tel: 0048 71 320 29 14
Email: andrzej.kolonko@pwr.wroc.pl

BRITISH TUNNELLING SOCIETY

16 DECEMBER 2010: **Baggage tunnel design and construction at Heathrow Airport**

Andrew Stephenson of BAA, Enrique Blanco of Ferrovial and Arthur Darby of Mott MacDonald give details on the challenges of constructing the tunnel under one of the world's busiest airports. ICE, 5.30pm for 6pm start.

20 JANUARY 2011: **East Side Access Project, New York**

The USD-7.3bn East Side Access Project currently under construction in the heart of Manhattan by the New York Metropolitan Transportation Authority Capital Construction Company is the largest federally funded infrastructure project in the USA. This talk will also present an overview of the multitude of tunnelling methods being used, including the first use of slurry TBMs in New York to excavate the 50,000 linear feet of tunnel.

17 FEBRUARY 2011: **Lesotho Highlands Tunnels - BTS / MinSouth Joint Event**

The Ingula Pumped Storage Scheme is the largest tunnelling project in South Africa. The location is just south of Johannesburg and just north of Lesotho. 12 km of 9.4m dia tunnels, 4 shafts (20m dia x 150m deep), 2 caverns, 200m x 20m spans.

17 MARCH 2011: **Green Park Step Free Access**

The works included a south-eastern extension to the existing ticket hall incorporating a ramp from the adjacent Green Park directly into the station, and the installation of two lift shafts. This presentation will discuss the development of the design and construction of the elliptical lift shaft and stub tunnel using SCL methods & escalator jacking system and the instrumentation and monitoring equipment employed.

21 APRIL 2011: **Harding Prize Competition**

The Competition is open to all aged 33 or under at the end of 2010. Entrants must submit an original paper relating to any aspect of tunnelling which they consider of interest to those in the tunnelling industry. The closing date for submission of papers is 28th February 2010.

19 MAY 2011: **BTS AGM + Limerick Immersed Tunnel**

The Limerick Tunnel will provide a new road crossing under the River Shannon The tunnel comprises five 100m long immersed tunnel elements, a cut and cover tunnel and approach ramps on each bank.

16 JUNE 2011: **High Speed Railway Tunnels in Spain**

Three separate major tunnel projects in Spain.

A DATE TO REMEMBER...

If you know of a tunnelling related conference, event, seminar or exhibition that is not listed here, we would be delighted to hear from you. Please contact the editor by post, email, fax or through our web site: Editor, 'Tunnels & Tunnelling International', Boundary House, 91-93 Charterhouse Street, London, EC1M 6HR, United Kingdom.
Fax: +44 20 7936 6826
Email: editor@tunnelsonline.info
Web: www.tunnelsonline.info

contacts



Jon Young

EDITORIAL

EDITOR

Jon Young

Tel: +44 20 7336 5256
Email: jyoung@tunnelsonline.info

TECHNICAL EDITOR

Maurice Jones

Tel: +44 01296 397 353
Email: mjones@tunnelsonline.info

NORTH AMERICA EDITOR

Nicole Robinson

Tel: +1 (612) 9402 780
Email: nrobinson@tunnelsonline.info

NEWS EDITOR

Alex Conacher

Tel: +44 20 7336 5257
Email: aconacher@tunnelsonline.info

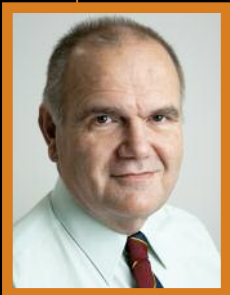
EDITORIAL SECRETARY

Tasha Denney

Tel: +44 20 8269 7833
Email: ndenney@tunnelsonline.info

REGULAR CONTRIBUTORS

**Adrian Greeman, Bernadette Redfern,
Patrick Reynolds**



Maurice Jones

PRODUCTION & DESIGN

DESIGNER

Natalie Kyne

TECHNICAL ILLUSTRATOR

Nick Stenning

PRODUCTION CONTROLLER

Loraine Lee

Tel: +44 20 8269 7799 Fax: +44 20 8269 7840
Email: llee@progressivemediagroup.com



Nicole Robinson

ADVERTISING

HEAD OF SALES

Shelly Palmer

Tel: +44 20 7936 6848
Email: spalmer@tunnelsonline.info

EUROPEAN SALES

Randolf Krings

Tel: +49 611 5324 416 Fax: +49 611 5324 519
Email: t&t@emcmedia.de

NORTH AMERICAN SALES

Clive Bullard

Tel: +1 845 231 0846
Email: cbullard@tunnelsonline.info



Shelly Palmer

CLASSIFIED AND RECRUITMENT

Tom Willard

Tel: +44 20 7936 6843
Email: twillard@tunnelsonline.info

ITALIAN SALES

Ediconsult

Tel: +39 02 477 10036 Fax: +39 02 477 11360
Email: milano@ediconsult.com

MARKETING MANAGER

Alex Farholm

Tel: +44 20 7336 5256 Email:
AlexandraFarholm@progressivedigitalmedia.com

HEAD OFFICE: World Market Intelligence

John Carpenter House, 7 Carmelite Street,
London EC4Y 0BS, UK

WEB ADDRESS: www.tunnelsonline.info

EMAIL: editor@tunnelsonline.info

TEL: +44 20 7336 5256

FAX: +44 20 7936 6813

HOW TO SUBSCRIBE

Subscription prices for 12 (24) months

Mailed anywhere in Europe €262.50 (€459),
USA & Canada \$258 (\$258), UK £110 (£188),
Rest of the world \$316 (\$553).

Send subscription and back issue queries to
Tunnels & Tunnelling Customer Services:
Email: cs@progressivemediagroup.com

Subscription Hotline:

Tel: +44 (0) 845 155 1845 (local rate)

Fax: +44 (0) 208 269 7277

Email: subscriptions@progressivemediagroup.com

Tunnels & Tunnelling Subscriptions,
World Market Intelligence,
Progressive House, 2 Maidstone Road,
Foots Cray, Sidcup, DA14 5HZ.
Subscribe online at www.getthatmag.com

HOW TO GET REPRINTS

The content of T&T is subject to copyright.
However, if you would like to obtain copies of
an article for marketing purposes high-quality
reprints can be supplied to your specification.
Please contact the advertising team for full
details of this service.

Tunnels & Tunnelling International is printed at
Stephens & George Print Group, Merthyr Tydfil.

BTS - EDITORIAL ADVISORY BOARD

Editorial Advisory Board Chairman:

Myles O'Reilly ME, PhD, CEng, FICE

Committee:

Keith Bowers MSc, PhD, CEng, FICE, MIMMM, FGS;

David Court CEng, FICE;

Ivor Thomas, CEng;

Roger Margerison BSc, CGeol, FGS;

Barry M New MSc, PhD, CEng, MICE;

Damian McGirr;

Andrew Smith CEng, MICE;

Ken Spiby, BEng;



All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage or retrieval system, without the express prior written consent of the publisher.

The contents of Tunnels & Tunnelling International are subject to reproduction in information storage and retrieval systems. Contact: University of Microfilms International, 300 N. Zeeb Road, Ann Arbor, Michigan 48106, US.

Tunnels & Tunnelling International ISSN number 0041-414X is published monthly for US\$226 a year by World Market Intelligence Ltd (www.worldmarketintelligence.com), a Progressive Media Group company, John Carpenter House, 7 Carmelite Street, London

EC4Y 0BS, UK. Periodicals postage paid at Rahway, NJ.
POSTMASTER: send address corrections to Tunnels & Tunnelling International c/o BTB Mailflight Ltd, 365 Blair Rd, Avenel, NJ 07001.
US agent: BTB Mailflight Ltd, 365 Blair Rd, Avenel, NJ 07001.

Tunnels & Tunnelling International and its Editorial Board accept no responsibility for the accuracy of statements or opinion given within the Magazine that is not the expressly designated opinion of the Magazine or its Editorial Board. Those opinions expressed in areas other than editorial comment may not be taken as being the opinion of the Magazine or its staff, and the aforementioned accept no responsibility or liability for actions that arise therefrom.



PROBLEM SOLVING UNDERGROUND



Once the contract is signed and site prepared, it's time to excavate. But even the best-laid plans can be slowed down by actual ground conditions. Robbins' advanced tunnel construction machinery, expert teams and innovative approach have successfully completed hundreds of boring projects around the world. From project planning to tunnel completion, we ensure your job is a success—no matter the obstacle.

Beyond Boring.

www.TheRobbinsCompany.com
sales@robbinstbm.com

