

FEBRUARY 2010

# tunnels & tunnelling INTERNATIONAL



## FOCUS ON DRILL AND BLAST

Reports from India's Pir Panjal railway tunnel and the UAE's Shis tunnel

## TRENCHLESS TECHNOLOGY

A look at the growing demand for trenchless equipment and pipe bursting safety



## ST. PETERSBURG: INGENIOUS ENGINEERING.


St. Petersburg is the most northern megacity in the world and its metro system is one of the deepest in the world. The Station Obwodny canal is located on line 5 at a depth of 60 meters. For a long time it was not put into operation, since the access shafts from the surface were not yet built.

The major challenge during mechanized tunneling of the 105 meter long escalator shaft was the gradient of 30°. The solution was a Herrenknecht EPB Shield with a diameter of 10.69 meters which started with a special launch construction – developed and produced by Maschinen- und Stahlbau Dresden. The TBM was kept on its path during tunnelling with an innovative system of lifting cables and hydraulic cylinders in accordance with the parameters of the VMT guidance system. Two rail-bound wagons, drawn by winches, provided for the removal of the soil material. They also transported the lining segments below ground, which were produced in formwork made by Herrenknecht Formwork GmbH.

Tunnelling went smoothly with the innovative machine made in Schwanau in the hands of the OAO Metrostroy specialists, achieving performances of up to 4 meters a day. The last lining segments could be installed in time for Christmas 2009 after only 12 weeks of tunnelling.

### ST. PETERSBURG | RUSSIA

#### PROJECT DATA

 S-441, EPB Shield  
Diameter: 10,700mm  
Cutterhead power: 1,200kW  
Tunnel lengths: 105m  
Geology: soft and hard clay

#### CONTRACTOR

OAO Metrostroy



# Contents

**FRONT COVER:**  
US firm McLaughlin has introduced the CBM 48 cradle earth-boring machine to help speed steel casing installation in the cross-country pipelines. (p38).

**WEB ADDRESS**  
[www.tunnelsonline.info](http://www.tunnelsonline.info)

**CONVERSIONS**  
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€0.72  
£0.63

- 5 COMMENT
- 7 WORLD NEWS
- 14 BUSINESS & FINANCE

## DRILL AND BLAST

16 INTERVIEW  
**Drill and blast developments**  
*T&T* sits down with Atlas Copco's Bjorn Rosengren, Mathias Edhammer, and Gunnar Nord

19 UNDER ARMED GUARD  
**Feeling the heat**  
*T&T* looks at how contractors on the Shis tunnel project in UAE dealt with extreme weather conditions, protecting explosives, and short-cutting locals

# 19

The travelling formwork for the cast insitu tunnel lining on the Shis road tunnel in the United Arab Emirates

23 PIR PRESSURE  
**Pir Panjal: NATM in the Himalayas**  
Building a NATM tunnel through the foothills of the Himalayas under snow and labour issued is posing a for the Pir Panjal project.

28 LETTERS



- 29 OBITUARY
- 30 PRODUCTS

# 42

## TRENCHLESS TECHNOLOGY

32 MEETING DEMAND  
**'No-Dig' techniques continue to advance**  
*T&T* looks at the latest advances in trenchless technology and how environmental demands are edging on the industry

36 SAFETY BURST  
**'No-Dig' techniques continue to advance**  
*T&T* looks at recent developments in trenchless methods

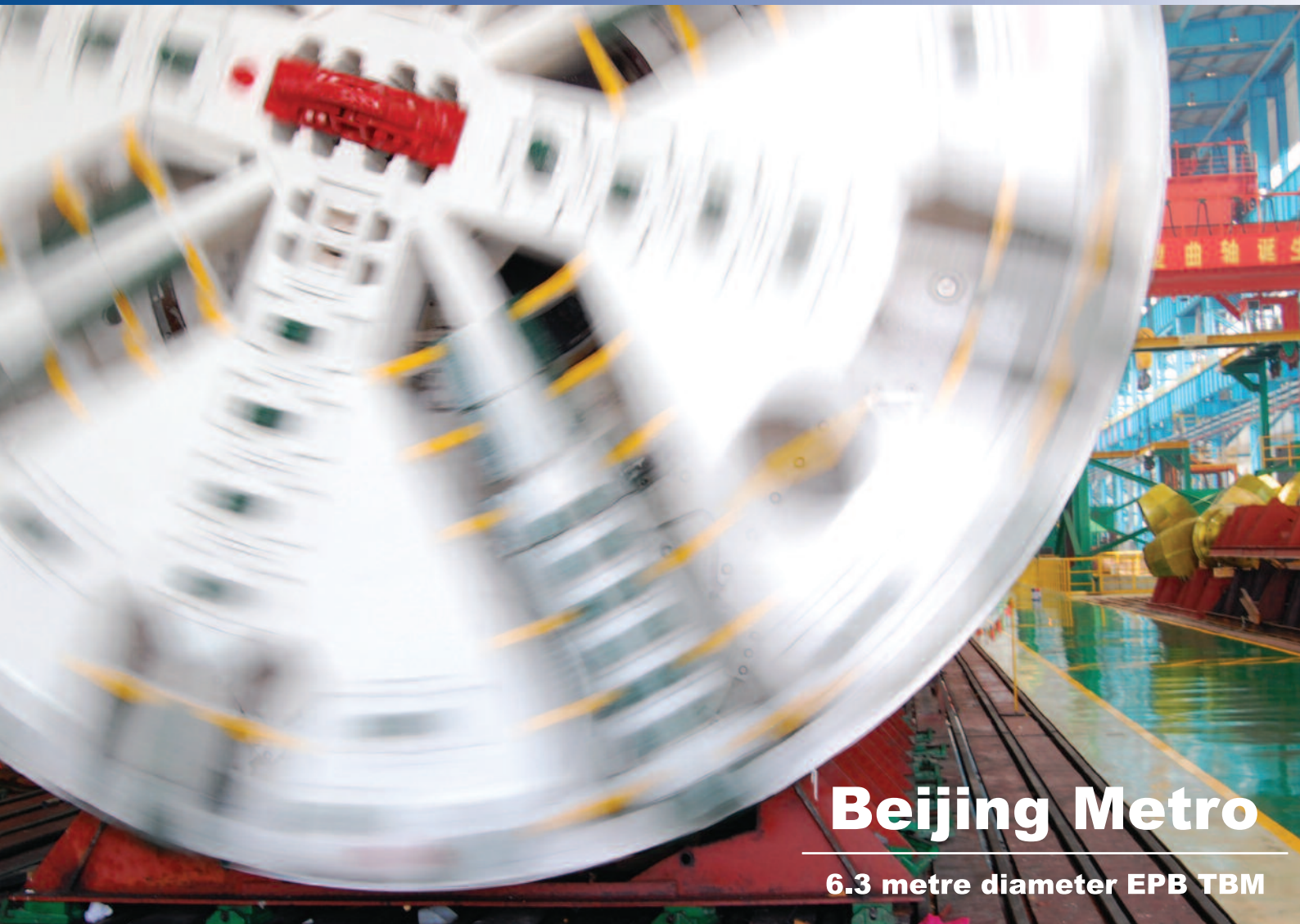
42 BRITISH TUNNELLING SOCIETY  
**Belfast Sewers Project - part 2**  
The November meeting of the BTS featured a presentation on the Belfast Sewers Project

46 CLASSIFIED ADVERTISEMENTS

49 DATES & EVENTS

Jacked caissons and dewatering allowed the contractor on the Belfast Sewers Project to sink dry shafts

# BREAKTHROUGH SERVICES



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6.3 metre diameter EPB TBM



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# The China syndrome

**M**ost, if not all, tunnelling businesses will be looking to China to boost their returns over the coming years as previously buoyant markets slow. Understanding the opportunities that exist in the nation and its neighbours, how to integrate with local business and at the same time protect the companies' self interest is probably the greatest challenge to overcome.

The size and importance of the market is plain. It was recently pointed out to me that some 70 per cent of China's Harmony Express high-speed rail line from Wuhan to Guangzhou runs on elevated track or through tunnels. There are 226 tunnels on the 968km route. With some 25 000km of track to be completed by 2012 it is hard to perceive a greater challenge for the tunnelling industry.

Many are already cashing in on this opportunity. Speaking at the T&TI conference in September Martin Herrenknecht told delegates he has 120 TBMs working in China. Manufacturers across the board have opened factories in the China to keep up with demand and benefit from the regions low production costs.

The industry is confident of China's potential. On page eight a digest of a recent outlook survey shows some two thirds of respondents expect positive growth in the region, with the rest largely expecting the economy to maintain its current level.

But there are drawbacks to entering the market. Manufacturers distributing in China have had difficulty getting repeat orders for equipment. Once in China it is quickly replicated and sold for less.

There are a couple of solutions being trialed. As

mentioned above, manufacturers are opening factories in China to take advantage of the low production costs. This helps the firm deliver a more competitive price locally but doesn't cover the r&d costs – which the replica hasn't incurred.

The second is a silver lining to the issue. On page 16, Björn Rosengren of Atlas Copco tells technical editor Maurice Jones about his move to Shanghai. Rosengren says one tactic is to keep developing new technologies and thereby staying one step ahead of the replicators. In this Atlas Copco is employing local skills and talent, of which there is plenty.

To keep selling to the largest tunnelling market in the world, manufacturers must keep developing new and more advanced solutions. If this is true, China will be a major driver of innovation and the industry worldwide will benefit. Watch this space.

Before I run out of space I'd like to welcome Kris Mole to the team. Kris has joined us as news editor after spending the past few years travelling Europe to cover transport news. London Daily Telegraph readers among you may already be familiar with Kris after one sharp-eyed commentator drew the hilarious link between 'Mr Mole' and tunnels. I've just been told The Independent has gone with the same angle.

And finally, tell us what you want! We have launched a dedicated email address to get feedback from the industry on what you want to see in the magazine. Tell us about obscure projects that you'd like to see covered or issues you'd like raised. Email: [ideas@tunnelsonline.info](mailto:ideas@tunnelsonline.info) We have our own, but we'd like yours too!

**Jon Young**



## COMPANIES IN THIS ISSUE

Arup	15	Connector Motorways	15	Indian Strategic Petroleum	14	Northern Railway	23
Ashmore Consulting	28	Costain	14	Insituform Technologies	35	Parsons Brinckerhoff	14
Atkins	14	Crosby Group	31	Interserve Project Services	14	Perforator	35
Akkerman	33	Cross City Tunnel group	15	Ircon International	23	PTP Contractors	13
Atlas Copco	16, 17, 18	Crossrail	14	Isolux Corsan	7	Rockmore International	31
Bachy Soletanche	14, 15,	DB Station & Service	14	J Murphy	14	Scottish & Southern Energy	7
Balfour Beatty	14, 15.	Deutsches Bahn	14	Judlau Contracting	13	Schiavone Construction	13
BAM Nuttall	7, 8, 11, 14,	Ditch Witch	33	Kier	14	Setracon	13
Barnard Construction	13	Dragages	15	KMI Water	14	Skanska	13
BASF Construction Chemicals	31	Ed Zublin	14	KordaMentha	15	Sound Transit	13
Black & Veatch	11	Engineers india	14	Lane Cove Tunnel Finance	15	Stirling Lloyd	30
Bohrtec	32	European Fire Sprinkler Ntwk	13	Lang O'Rourke	14	Strabag	14
Bombardier Transportation	15	Fitch	15	Maeda	15	Taylor Woodrow	11, 14
Bouchier Precast	0	Gammon Construction	15	MCE Lasers	31	Thames Water	8
Brawoliner	36	General Mechanics	21	mcLaughlin	32	Traylor Brothers	9
BTA Institutional Services	15	Geoconsult - Rites	23	Moodys	15	Tutor Saliba	7
Capita Symonds	14	Gobain PAM UK	30	Morgan Est	14, 28	Vermeer	33
Chew Tai-Chong	15	Halcrow	19, 20	Morgan Est - Farrans	42, 43, 45	Yuksel Insaat	11
Comsa	7	Herrenknecht	32	Mott MacDonald	14		
Conjet AB	30	Hindustan Construction	14, 23	MTR Corporation	15		

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# Blaze in Northern Spain tunnel

**F**ive workers were injured last month when a fire broke out in a railway tunnel under construction in Spain. The incident happened in the 2.5km Vega del Ciego tunnel that will form part of the high-speed rail line between Madrid and the Asturias region.

The construction joint venture of Isolux-Corsan & Comsa (ICC) claimed that a spark in a sheet of waterproofing caused the fire that then burned the tunnel's lining. ICC declined to comment further. Spanish police were on site investigating the fire as *T&T* went to press.

All work has been halted until cleanup is completed. It is not known how long it will take.

The fire burned for nearly six hours, with more than 30 firefighters, mine rescue workers, ambulance workers and police involved in the control of the blaze.



The five injured workers were treated for smoke inhalation and were all discharged the same day.

The fire burned part of the tunnel's lining, a generator, rolls of unused waterproofing and several

bits of machinery. The client, Spanish railway operator Adif's technical personnel were on site, checking the tunnel and the machinery to assess the scope of damage caused by the fire. An Adif spokesman considered the damage of "little regard."

Firefighters entered the tunnel from the southern portal and found the fire and heavy smoke about 500m in. Fire chief Jaime Martin said that his men could hardly see through the smoke and that

**Above: Emergency services at the Vega del Ciego tunnel**

breathing apparatus was necessary at all times. A fire hose stretching one mile was used to extinguish the blaze. Once the fire was extinguished workers ventilated the tunnel and cooled all hot spots detected by thermal imaging cameras.

The tunnel is part of the 4.9km subsections linking the towns of Campomanes and Pola de Lena.

## Construction on Caldecott begins

**C**onstruction began on the 1.3km long fourth bore of the Caldecott Tunnel last month. The four year US\$420 million project will run between Oakland and Contra Costa County on Highway 24 and is aimed at alleviating traffic congestion in the area.

Tutor-Saliba is constructing the two-lane 12.5m wide bore for a partnership between the California Department of Transportation (CALTRANS), the Contra Costa Transportation Authority (CCTA) and the Alameda County Congestion Management Agency (ACCMA). It was awarded the contract last September.

Excavation from both ends is expected to start in June. It will be constructed using NATM. Roadheaders are expected to be used for most of the excavation but some drill and blast might be performed through harder rock. One to two metres per day will be excavated. The support for the tunnel will primarily include rock bolts, lattice girders and shotcrete.

A spokesman for the project told *T&T* that one of the main challenges in construction will be

disposing of the spoil as a site for this has not been found.

"Blasting may also be an issue. The limitations on blasting are quite restrictive; no night blasting. Daytime blasting requires the closure of the third bore, which according to the traffic plan, can only be closed for a short period of time near midday. Of course, other operation must be halted before blasting can occur," the spokesman told *T&T*.

Seven cross-passages to the third bore will be built to provide emergency exits.

Work is scheduled for completion in spring 2014 and will eliminate the need for the existing central tunnel to alternate between westbound and eastbound traffic during rush hour.

Orinda councilor Amy Rein Worth who fought for the project for years before seeing it get the go-ahead said, "Given the decades it took to put this project together, four years will seem like a very short time."

Bores one and two were opened in 1937 and the third added in 1964. Some 160,000 commuters use the tunnel daily.

## Glendoe diversion tunnel works start

**C**ontractors were last month due on site to start works on the new diversion tunnel at the Glendoe hydroelectric scheme in Scotland.

Bam Nuttall was awarded the contract by the station's owner Scottish and Southern Energy (SSE).

A rockfall blockage in the tunnel was realised last August, rendering the plant non-operational. SSE confirmed the rockfall as "very substantial", up to 20,000t according to project sources.

SSE did not reveal the cause of the collapse, which happened in the upper third of a 6.2km headrace tunnel that carried water from the reservoir in the Monadhliath Mountains to the powerhouse close to Loch Ness.

Bam Nuttall declined to comment on the project, however a project source confirmed the

contract award. The source told *T&T* that the tunnel would be excavated by drill and blast. The collapsed tunnel was excavated by TBM.

SSE said in November that the work needed to repair the tunnel was so extensive that it didn't expect the power plant to be operational before 2011 (*T&T*, December 2009, page 11).

A significant proportion of the funding for the repair project, thought to be £20M (US\$32.4M), will be covered by contractual arrangements and insurance, according to SSE.

The ground conditions on site comprise interbedded quartzites and schists with little or no groundwater.

The headrace excavation was completed two years ago. The Queen formally opened Glendoe last June, just two months before the collapse.



The Tideway Tunnels will carry sewerage to the Beckton Treatment works

# Councils to fight Thames Tideway plans

Two London borough councils have slammed the government's plans to move the Thames Tideway Tunnel project onto the Infrastructure Planning Commission (IPC).

The boroughs of Hammersmith & Fulham (H&F) and Kensington & Chelsea (K&C) said that ministers are bypassing the local democratic process to secure planning permission for the £2.2bn (US\$2.2bn) project.

The councils claimed the tunnel is not at the threshold required for the IPC, a government-established organization with the power to decide planning applications of

national importance, such as airports and power stations. They claimed that the Department for Environment Food and Rural Affairs (DEFRA) will invoke special powers to push the tunnel plans through.

The councils claimed that constituents' views on the tunnel will be ignored despite the fact that they will pay for the project through increased water rates.

They said that if the tunnel is of national importance then it should be paid for by the whole nation. H&F cabinet member Paul Bristow said, "If Londoners are to pay for this scheme then we have a democratic right to decide

whether or not we want it."

According to H&F council, residents will "endure nearly a decade of construction misery." The council also claimed that parks and open spaces such as Furnivall Gardens will be blighted by the work. It argued that the project will not bring enough improvements to justify the cost or the damage to residents' lives.

A DEFRA spokeswoman said any decision to actually refer the project to the IPC would be taken in 2011 at the earliest. She added that all interested parties would be able to participate in the consultation process.

The tunnel is an eight year project designed to stop sewage flowing into the river at times of heavy rainfall. It needed for the UK to meet the EU Urban Waste Treatment Directive.

The councils argued a shorter tunnel would be a better option. They urged Thames Water to examine more sustainable long-term solutions such as the separation of sewage and floodwater instead of the combined drainage system.

A Thames Water spokeswoman told *T&T*, "We will work hard to provide all interested parties with meaningful opportunities to have their say."

## Blackwall Tunnel Upgrade

The Blackwall tunnel is to get a 21st Century upgrade, Transport for London announced on Thursday. The three year £49M refurbishment programme of the northbound tunnel will be undertaken by BAM Nuttall and will begin on 7 February.

The upgrade will improve safety, lighting and communications systems in the 112 year old, 1,364m long tunnel.

New fire and incident detection systems, better access for emergency services, and a new CCTV camera system will be installed in the tunnel.

The work will be done at night to minimise disruption to road users. The northbound tunnel will be closed between 21:00 and 05:00 Sunday to Friday during the project. Northbound traffic will be diverted through the southbound tunnel during this time, while southbound traffic will be able to use other river crossings.

"We are doing everything we can to ensure the refurbishment

of the tunnel is carried out with the minimum disruption to road users, and we ask people to bear with us while these important safety improvements are carried out," said TfL Streets chief

operating officer Garrett Emmerson.

The tunnel was built in 1897 to transport horse-drawn carriages under the Thames. Over a century later it carries 50,000

vehicles a day. It carries one of London's busiest commuter roads, the A102, under the river between the boroughs of Greenwich in the south and Tower Hamlets in the north.

## Emerging markets boom

Construction in emerging nations is set to increase over the next twelve months while developed markets can expect slower growth or in some cases a decline in activity. India and China can expect to see double digit growth in the construction industry in 2010.

The findings, from a survey conducted by World Market Intelligence, were published in the Construction Industry Outlook: Q1 2010 report. Over 780 senior industry members took part in the survey, including buyers, contractors, sub contractors,

designers and architects.

Sixty percent of respondents expected positive growth in India and China. Twelve percent expected very strong growth in India, while nine percent thought the same for China.

Five percent of respondents expected very strong growth in the Singapore, Taiwan and Hong Kong region.

These results were in contrast to what respondents expected for developed economies. Seventeen percent of respondents expected the construction markets of Japan and the USA to experience no

growth, while twenty-three percent expected the same of the UK.

Two percent of those surveyed expected the UK to suffer a very strong decline in 2012, equal to that of Eastern Europe and Canada.

The report aimed to identify key global trends affecting the construction industry. It covered category-level spending outlooks, supplier selection criteria and procurement budget expectations of decision makers. The report also examined buyers' and suppliers' growth, mergers and acquisitions and investment expectations.

# Ottawa proposed tunnel splits opinion

A row broke out in Ottawa, Canada last week between city councillors over the council's approval of a new 3.2km light rail tunnel. Councillors were at loggerheads over whether or not the tunnel would relieve congestion and cut journey times.

The approval enables the city to begin property procurement and an expedited environmental assessment of the corridor.

The tunnel will form part of the city's 13.5km light rail system east-west corridor between Tunney's Pasture in the east and Blair Station in the west. The tunnel will begin just east of the Lebreton Station and will finish just south of the University of Ottawa Station. It will hold four stations: Downtown West, Downtown East, Rideau Centre and University of Ottawa Station.

Councillors voted 19-4 in support of the plan.

The chairman of the city

council's transit committee Councillor Alex Cullen, who voted for, said the project was the "appropriate choice for the future."

He told *T&T* the tunnel would ease congestion and "provide speedier, more reliable rapid transport through the downtown, where the bulk of the city's jobs are."

Councillor Clive Doucet, who voted against, rubbished the claim, saying "it will not increase cross-town speeds because it will require a transfer to buses at each end and the stations will be ten stories down and up to half a kilometre away for many riders."

Doucet also claimed that it would take at least 15 years to implement and would be a massive draw on the council's funding, diverting money from other transport works.

The estimated cost of the twin bore tunnel is CA\$735M (US\$691M) while the whole

project is estimated at CA\$2.1 billion (US\$1.9bn). The province of Ontario has already pumped CA\$600M (US\$564M) into the project.

Doucet questioned how the council could budget CA\$2bn (US\$1.89 billion) for the first stage of the tunnel when "we can't afford a universal pass for students that will cost \$200,000 (US\$189,000) and we're cutting bus lines."

Doucet is a proponent of surface light rail and is against putting the "environmentally friendly" electric rail underground.

He added that seismologists told the council that the massive amount of tunnelling might disturb the north-south fault line that the city sits on.

According to Cullen, the procurement stage is still about a year away.

## Traylor scoops award

Chief executive officer of US contractor Traylor Bros Thomas Traylor has been awarded the Moles' Outstanding Achievement Award for 2010.

The Moles, a national committee of heavy construction professionals based in New Jersey, will present the award on 27 January in New York City.

The Moles has presented two awards for outstanding achievement in heavy construction each year since 1941; one to a member, one to a non-member.

Traylor told *T&T*, "The Moles' Member award is most appreciated by our Traylor Team. What a great honour for us all!"



The TBM will bore Mexico City Metro's new line 12

## Mexico's largest TBM completed

Construction of Mexico's largest ever TBM was completed in January. The 10.2m diameter Robbins EPBM was assembled for the ICA Consortium (ICA, CARSO, and Alstom) at the jobsite in a 17m deep launch shaft. It will be used to bore a 7.7km long tunnel for Mexico City Metro's new Line 12, starting in the first week of February.

Crews assembled the machine in a concrete cradle at the shaft bottom using gantry cranes to lower in components including the front and rear shields, cutterhead, and screw conveyor. It is the first EPBM to be assembled at the jobsite using Onsite First Time Assembly (OFTA).

ICA tunnel manager Ismail Benamar said, "With proper project management and fit up of components, OFTA can save about 70 - 80 per cent of the time

required for a similar assembly at a shop."

The TBM is designed to work in Mexico City's harsh ground conditions. Layers of clay, sand and boulders up to 800mm in diameter are expected, as the area is part of a drained lakebed. A two stage, 1.2m diameter ribbon-type screw conveyor will be used to handle the large boulders. The TBM will excavate the first 70m of the tunnel using umbilical cables connected to back-up gantries on the surface. Gantries will be lowered into the shaft successively as the machine bores forward.

Mexico City officials celebrated completion of the TBM with a cutterhead turning ceremony. The Mexico City Metro is one of the world's largest, with over 200km of rail and nearly four million daily passengers.

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# Charleston sewage threat

A tunnel failure could leave 30,000 homes and businesses without working sewers.

The sewage tunnel in South Carolina is in imminent danger of failure due to sporadic backups of raw sewage. The problem is capacity; the pipe can not handle the amount of sewage being pumped through.

Charleston Water System has asked U.S. House Minority Whip

Jim Clyburn for US\$16 million in federal assistance to go toward the estimated US\$43 million project. The aid was previously authorised by Congress but was never approved.

Charleston Water System has been issuing warnings about the status of its deep sewer tunnels for 18 years and has replaced all but one.

The scheme, which is being overseen by Black & Veatch (B&V),

is entering final design stage and will be ready to bid within 12 months. It will take 30 months to complete construction.

T&T tried to speak to B&V about the project but they declined to comment.

Clyburn warned Charleston Water System in January that it will have to defend the spending if he pursues the US\$16 million earmark.

The two mile tunnel sits more

than 30m below the ground. It was built in the late 1960's.

The project would add a new tunnel section to increase sewer capacity, creating space for the waste that new developments are expected to generate.

Failure of the current tunnel would mean no sewer service for West Ashley and parts of Johns Island, Red Top, Hollywood, Meggett and Ravenel.

# 'Futuristic' tunnel opens in Qatar

Qatar's Ras Abu Aboud cut and cover tunnel opened last month. It forms part of the Ras Abu Aboud Road project. The project, a joint venture between Yuksef Insaat and local contractor MIDMAC began in 2007 and was completed in October 2009. The tunnel took

one year to complete.

The US\$200M project involved the construction of new bridges, two underpasses and the 350m tunnel.

The New Doha International Airport (NDIA) Steering Committee oversaw the project. The tunnel, regarded as a vital central feature of the airport links Wakrah Road and Doha's waterfront promenade, the Corniche.

Qatar Civil Aviation Authority chief executive officer and NDIA

Steering Committee chairman Abdul Aziz al-Noaimi told T&T that the main challenge encountered during construction of the tunnel was excavation in hard-rocky sub layers approximately 12m below ground level.

Dewatering also posed a challenge as the tunnel was just 200m from the seashore. Round-the-clock dewatering pipes were employed during excavation and concrete placement.

Al-Noaimi said, "The tunnel walls were fairly stable due to the presence of rocks and stable subsurface conditions. Some

shoring means were put in place to ensure stability of the slopes during the excavation process."

The 16m wide tunnel features many hi-tech attributes including light and sound alarms triggered by vehicles exceeding the 5.5m height restriction. Additional technology controls pollution levels and monitors speed.

Al-Noaimi praised the tunnel at its opening ceremony. He described it as being "a futuristic street, integrating drainage networks, water irrigation system, electrical and communication cables, as well as security devices."

## Major Upgrade to Tottenham Court Road

Transport for London has awarded a BAM Nuttall and Taylor Woodrow joint venture the contract to upgrade Tottenham Court Road tube station.

The contract is worth some £250M (US\$403).

Construction is due to begin in early 2010. The project will take 80 months with a target completion date of September 2016.

The station will be enlarged to twice the current capacity, including a ticket hall almost six times larger than the existing one.

Additional features include new station entrances, a new concourse linking the tube station with the overground one, and modernization of the existing passageways and platforms. More escalators and five lifts will provide step free access throughout the station. A new ticket office will also be created for Crossrail.

Tottenham Court Road tube station was opened in July 1900.

**Below: The 350m tunnel was completed in one year**



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# Korea-Japan undersea tunnel talks

**M**omentum is mounting for plans to construct an undersea tunnel connecting Japan and Korea. A 200km undersea tunnel running from Busan in South Korea to the Japanese Island of Kyushu would link the two countries by a high-speed rail line.

Discussions on the topic have been taking place for almost thirty years, but only now is the idea being given serious consideration.

Construction costs are estimated at around Y60 trillion (US\$52.1 million) to Y100 trillion (US\$86.9 million).

It is thought the project would take between seven and 10 years to construct.

A tunnel building committee was established this month by a

research group from the two countries, according to Japanese Prime Minister Yukio Hatoyama, who first revealed the plans late last year on a visit to Seoul.

The Korea Japan Tunnel Project Association in Busan and the Japan-Korea Tunnel Research Institute, a non-profit foundation in Tokyo, are leading the research.

Studies on the tunnel have been initiated mostly by the private sector, according to local media reports.

Government support is expected to follow, as the scope for boosting economic development is revealed.

Researchers, politicians and entrepreneurs, who recognise that the tunnel could boost economic development in the region as well

as cementing international relations between the two nations, are championing the idea.

The tunnel will facilitate bilateral trade, which rose from approximately US\$40 billion in 1999 to more than US\$89 billion in 2008, and will reduce freight and shipping costs. It will also be a boost for the Eurasia transportation link.

Speaking to local media, Prof. Shin Jang-cheol of Seoul's Soongsil University said: "The tunnel will stimulate business, ease tension and promote political

stability in East Asia. It will also have a positive impact on the reunification of the Korean Peninsula."

In 2009, approximately 20,000 people travelled between the countries daily.

One economic issue that will be faced by rail companies utilizing the tunnel is that of different sized rail gauges, if the rail system is eventually connected to the Trans-Siberian Railway via China. Russia uses a 1520mm gauge, while Korea uses 1435mm and Japan 1067mm.

## Construction delay on THE Tunnel

**C**onstruction of the Trans-Hudson Express (THE) Tunnel could be delayed by four to six months due to ownership issues regarding the properties on the West Side of Manhattan.

The port authority of New York and New Jersey pledged \$3bn towards acquiring buildings and obtaining permission to bore under others. Its lawyers were negotiating with the city over how much public notice is required before the Port Authority can condemn the property it wants.

The required notice could affect the tunnel boring contracts for the 6.5km twin bore tunnels that were awarded in December and January. New Jersey Transit and the Port Authority awarded the joint venture of Barnard Construction and Judlau Contracting the \$583M contract for the design and construction of the Manhattan side of the tunnel. PTP Contractors, a JV between Schiavone Construction, J F Shea Construction, and Skanska USA

Civil Northeast was awarded the \$271.7M contract for the final design and construction of a tunnel cutting through the Palisades between North Bergen and Hoboken.

Some local businesses objected to the taking of their property to build a train terminal that will be just a block away from Pennsylvania Station, Herald Square subway and the PATH train station. The new commuter terminal will sit more than 120ft (36.5m) beneath 34th Street and was not designed to connect directly to Penn Station or the subway.

The THE Tunnel, which broke ground last June, is scheduled for completion in 2017. The project is designed to double the existing trans-Hudson rail capacity from 23 trains per hour to 48 per hour. The US\$8.7bn project is one of the biggest public works projects under way in the US.

The extra train service is expected to eliminate 22,000 car journeys a day.

## Frankfurt safety & security event

**S**P Technical Research Institute of Sweden is organising the Fourth International Symposium on Tunnel Safety and Security (ISTSS) to be held in Frankfurt, Germany on 17-19 March.

Themes of the symposium will be risk & security, human behaviour in tunnels, passive and active fire protection & construction, fire fighting, ventilation and fire dynamics. Keynote speakers are scheduled to open each of the two and a half days of discussions. These are:

Kenneth Cummins, chief security officer, Sound Transit (Greater Puget Sound Regional Transit Authority), Seattle, US; Jeffrey A Slotnick, Setracon Inc., US – security industry consultant; Dr Anders Lönnermark, senior research scientist at the Department of Fire Technology, SP Technical Research Institute, Sweden; Alan Brinson, executive director, European Fire Sprinkler Network, UK; Prof Reinhard Ries, chief fire & rescue officer, Frankfurt am Main Fire & Rescue Services, Germany; Prof Arnold Dix, independent technical & legal tunnel risk

adviser, Queensland University of Technology, Australia.

Honorary sponsors include the ITA, ITA-COSUF, the NFPA, the International Road Transport Union Academy, and the International Association for Fire Safety Science.

Other scheduled speakers will come from Australia, Austria, Canada, Finland, France, Germany, Greece, Italy, The Netherlands, Spain, Sweden, Switzerland, Taiwan, the UK, and US.

The official working language of the symposium is English. There is an optional banquet on Thursday 18 March and a visit to the Frankfurt Metro fire test facility on 19 March.

The organiser, SP Technical Research Institute of Sweden, develops and disseminates technology to assist the development and competitiveness of industry, to improve safety in society, to support sustainable development and to help protect the environment. The Fire Technology department has performed text and done research in tunnel safety since 1992.

T&I is media partner of ISTSS 2010.

## Crossrail and Bond street

Crossrail has awarded its final five design contracts totalling £13.8M (US\$22.3M), and its parent Transport for London (TfL) has called on the three prequalified JVs to submit bids for redevelopment of Bond Street station on the middle of the new line.

Three of the last design contracts on the Crossrail project were awarded last month to Mott MacDonald, the others being picked up by Parsons Brinckerhoff and Atkins, respectively. In total, 24 design contracts have been awarded.

Motts won design contracts with a combined value of £10M (US\$16.2M) for Material & Workmanship Specifications (Package C102), the Paddington Integration Programme (C131) and Rolling Stock and Depots (C160). The contract values are £3.5M (US\$5.7M), £4.5M (US\$7.3M) and £2M (US\$3.2M), respectively.

The design contract for Custom House station (C146) was awarded to Atkins for £2M (US\$3.2M).

Parsons Brinckerhoff won the Communications & Control Systems design contract (C170), which is valued at £1.8M

(US\$2.9M).

Preparatory work is underway on the site where a tunnel portal will be built at Royal Oak in west London. The construction contract will be awarded shortly. The design contract (C150) is with Capita Symonds, which also has the contracts (C156) for the North Woolwich and Plumstead portals.

Crossrail added that by the end of this year construction work will be underway at all new central section stations, tunnel portals and shafts. Main tunnelling with TBMs is to get underway from late 2011 from Royal Oak to east drive to Farringdon. Shortly after the westbound bores will begin from Docklands to Farringdon.

Almost 42km of 6.2m i.d. tunnel is to be bored for the £15.9bn (US\$) twin-tube line that will run east-west through the heart of London. Crossrail said six EPBMs are to be used, and the two main tunnelling contracts are out to tender.

Separately, TfL is looking for bids from Balfour Beatty and JV of Taylor Woodrow and BAM Nuttall, and JV of Laing O'Rourke, Bachy

## Padur oil cavern job for HCC

Hindustan Construction (HCC) has been awarded the contract to excavate a crude oil storage cavern at Padur in the state of Karnataka.

HCC secured the contract worth Rs 374.66 Cr (US\$80.8M) two years ago from Indian Strategic Petroleum Reserves, which is part of the country's Oil Industry Development Board itself part of the Ministry of Petroleum & Natural Gas.

Key activities involved in the contract to construct the unlined rock storage include geological mapping, detailed engineering and design, and excavation of a number of structures ranging from access tunnels, water curtain galleries and shafts to the main cavern to hold the oil.

Engineers India is the client's project management consultant on the contract, which is one of two caverns - Part A and Part B to be built at the site. HCC was awarded the contract for Part A.

The caverns will have D-shaped cross-sections and be approximately 20m wide and up to 30m high. The oil is to be sealed within the caverns by the saturated rock mass and flowing groundwater.

The national agency plans to construct a number of the caverns and HCC is already excavating the first of the storage structures at Vishakhapatnam in the state of Andhra Pradesh.

The Padur project will take three years.

## Leipzig contract for Zublin

Ed Zublin has been awarded a contract for fit-out and finishing work on some underground stations of the City Tunnel project in Leipzig, Germany.

The €75M (US\$108M) contract calls for construction work on four underground stations of the metro link running through the heart of the city. The stations are Hauptbahnhof, Markt, Wilhelm-Leuschner-Platz and Bayerischer Bahnhof.

Heavy construction work on the project is almost finished and the fit-out and finishing work is to start on site in June for completion by the end of 2012.

The new contract involves lining walls and ceilings, covering floors, and installation of metal furniture and safety barriers, ventilation, water and wastewater systems. In addition, the job requires installation of electrical, security and information systems as well as escalators and lifts.

The contract was awarded by DB Station & Service AG, part of Deutsches Bahn. The job is to be handled by the company's Sachsen branch office, said parent group Strabag.

Soletanche and Costain for redevelopment of Bond St station. Deadline for submissions is April for award by mid-year. Morgan Est, the fourth party that had prequalified, pulled out in December.

At the end of last year the client awarded a contract for redevelopment of Tottenham Court Road tube station to a JV of Taylor Woodrow and BAM Nuttall.

## KMI get Preston contract

The £114m (US\$184) Preston storm water contract was last month awarded to KMI Water. The project involves the construction of a 3.5km tunnel that will hold 40 million litres of storm water to prevent the River Ribble from overflowing.

KMI, a joint venture between Kier, J Murphy and Interserve Project Services, were awarded the contract by United Utilities.

A new terminal pumping station will be constructed at Penwortham. It will connect the 30m below ground tunnel to a wastewater treatment works facility in Clifton Marsh.

The tunnel will include five sewer overflow shafts to spill flows into the new Interceptor / Storage tunnel system via connecting micro-tunnels.

The project is expected to be completed in late spring 2012.

## Tewent wins Brazil contract

Spanish company Telvent was last month awarded a €14.5M (US\$20.2M) contract to install its Telvent SmartMobility Tunnel solution on Brazil's El Morro Alto Tunnels.

The project marks the first step in accomplishing one of Brazil's Department for Infrastructure and Transport, Departamento Nacional de Infra-Estrutura de Transportes (DNIT)'s highest priorities; enhancing safety and security on its road and rail infrastructures.

Telvent's chairman and chief executive officer Manuel Sanchez said, "We are pleased to be able to collaborate with the Brazilian Transportation and Infrastructures Authority in enhancing Brazilian critical infrastructures safety and security with the aim of reducing accident rates".

The contract allows Telvent to strengthen its position in the Brazilian market. The Company has completed numerous projects in Brazil.

# MTR awards more WIL, XRL contracts

**M**TR Corporation has awarded more contracts on the West Island Line (WIL) and Express Rail Link (XRL) projects, and also appointed a new projects director.

Gammon Construction has won the second tunnelling contract on WIL in Hong Kong to be awarded by MTR Corporation. The HK\$1.344bn (US\$173M) contract calls for construction of Kennedy Town station and Overrun Tunnel (Contract 705).

One of Gammon's joint owners, Balfour Beatty, said the contract aims to achieve new standards in noise reduction and dust suppression in construction works in Hong Kong.

The first tunnel contract on WIL was signed in October last year between MTR and a joint venture of Dragages, Maeda and Bachy Soletanche Group. The JV was awarded the HK\$1.6bn (US\$206M) job – Contract 703 – to build the section between Sheung Wan and Sai Ying Pun stations.

WIL will extend 3km from the existing Sheung Wan station to Kennedy Town and is to be finished in 2014. The third, and final, tunnel contract on the project is Contract 704 between Sai Ying Pun and Kennedy Town which is due to be awarded in the first quarter of this year.

On the Hong Kong section of

the XRL project, MTR has called for prequalification of contractors to bid for the West Kowloon Terminus Station South section of the scheme (Contract 810B). Deadline for submissions is 29 January, and tenders for cut and cover works are due in the second quarter.

The adjacent section of cut and cover works, for the approach tunnels to West Kowloon station, are at tender stage and the award of the north and south sections (Contracts 811A, 811b) are expected in Q2.

The contract for dust monitoring during construction of XRL was awarded to Arup late

last year. The job (Contract 8205) is valued at approximately HK\$4.74M (US\$0.6M).

The section of XRL in Mainland China, between Guangzhou and Shenzhen, is due to commence operations next year. The approximately 26km long tunnelled section of the twin-tube link in Hong Kong is to be completed by 2015.

The company has named Chew Tai-Chong to be projects director from the beginning of this month, succeeding Russell Black who retires. Chew previously worked with Bombardier Transportation and Singapore's Land Transport Authority (LTA). Black has been projects director since 1992.

# Receiver takes reins at Lane Cove tunnel

**T**he owner and operator of Lane Cove toll Tunnel in Sydney, Australia – Connector Motorways – has been put into the hands of the Receiver.

KordaMentha (KM), which was appointed as Receiver and manager by Connector Motorways' security trustee BTA Institutional Services Australia, is exploring options for the 3.6km

long link, including a possible sale.

KM said the plan is to put the tunnel assets on a firm financial footing and one option considered would be a sale disposal. The toll tunnel will continue operating despite the business setback.

The privately financed twin-tube tunnel opened three years ago slightly ahead of schedule but traffic volumes have been

lower than projected and, consequently, revenues weaker.

In late 2008, credit ratings agencies Fitch and Moody's turned negative on the toll tunnel venture, their focus being on Lane Cove Tunnel Finance, the financing arm of Connector Motorways. They noted then that there was sufficient liquidity to meet cash calls to at least mid-2009.

Traffic volumes increased 9 per cent over the last year, noted the Receiver. Over the last six months the company also raised the tolls twice in its first

adjustments for inflation.

Despite the slight improvement the Receiver was called in and no significant changes are planned to tunnel operations, said KM.

The problems for Lane Cove follow previous revenue difficulties across the city at the Cross City toll tunnel, which also saw KM called in to act as Receiver.

In June 2007, the owner and operator, Cross City Tunnel Group, was sold to a consortium led by ABN Amro and Leighton Holdings.



# Drill and blast developments

Atlas Copco senior executive vice-president (Construction & Mining Technique – CMT – Business Area) Bjorn Rosengren tells technical editor Maurice Jones about his planned relocation to Shanghai and Mathias Edhammer, product marketing manager for Boomer drillrigs and Gunnar Nord, senior construction adviser (underground equipment) of the manufacturer talk about their latest drill and blast developments

## When do you plan to move your office to Shanghai?

**Bjorn Rosengren:** On 1 August this year.

## How will other divisions be represented there, and from approximately what time?

**Rosengren:** We'll be carrying out an evaluation over one year before we decide whether divisions need to move to China. Each of the eight is already well established in China including Underground Rock Excavation and Secoroc. The divisional presidents will not be moving.

## What do the existing Atlas Copco group companies in China produce?

**Rosengren:** There are eight Atlas Copco companies in China operating six factories. Those concerned with tunnelling are both in Nanjing. The city is also home of our centre for technical research, design and development, plus the national Customer Centre. Factories in other cities produce Dynapac products, drill tools, construction tools, etc.

## What end use sectors are the main markets for drill and blast tunnelling in China, e.g. rail transport, road transport, urban, transnational, water supply, etc?

**Rosengren:** Hydropower and other water projects are particularly important. Our

general sales manager in China, Freddie Man says there are around 100 hydropower projects planned or in construction, of which 20 are very large. Next are high-speed rail projects, especially to develop the west of the country. Oil storage projects are very interesting, mainly on the east coast, with the first scheduled to go out to contract soon.

## How does China's regional geography and geology affect the demand for tunnelling product types?

**Rosengren:** You are asking the wrong person about geology, but the conditions in the west of China are very demanding on drillrigs with harder, more fragmented rocks and seismic movements. The country itself is also tough with difficult topography and sometimes arid. Yet this is where the main infrastructure development is needed.

## You have mentioned the need for technical developments to keep one-step ahead of imitators in view of weak legal restrictions. How will Atlas Copco expect to accomplish this? Will, for example, technical development be 'imported' or 'home grown' for local needs?

**Rosengren:** Apart from the occasional sophisticated product, we are developing locally for the Chinese market. The trend is clear. We need to produce in China to sell in China, and we also need volume. Our r&d is to develop cost-effective products for the Chinese market using Chinese resources, not just technology transfer. That is achieved by producing better performance at lower cost with more locally developed products.

## What training schemes does Atlas Copco operate or sponsor in China, and at what levels?

**Rosengren:** We are setting up a training centre for operators and craftsmen in Nanjing. The Chinese university system is producing highly qualified engineers whom we can employ on r&d etc.

## What are your thoughts on China generally?

**Rosengren:** It's all most exciting going forward, to develop such a growing market with its own resources. Of our eight general managers in China, seven are Chinese, as are all our r&d staff. And there are many large projects to supply. Other Swedish companies - Skanska, NCC and Volvo for example, are also here for the oil storage and other schemes.

## The conventional layman's view of China and other Asian countries is that construction is labour intensive, but the number of TBMs reported in China gives the lie to this. Is there a similar demand for high-speed, high precision drill and blast tunnelling (HPT)?

**Rosengren:** Drill and blast work is still labour intensive but, particularly in large projects, there is a demand for the higher productivity of more advanced equipment. Our main r&d effort in China is aimed at producing cost-effective products particularly for the Chinese market. Our factories there now produce the majority of the products we sell in China, although the more sophisticated products are imported from Sweden and the US.

## Is the demand for HPT rigs and the integrated systems likely to grow there compared to direct-control hydraulic rigs?

**Rosengren:** As yet there is limited demand for HPT systems, with less than ten computerised tunnelling rigs in China (on major projects), but Freddie Man, assures me that it will move in that direction. There is already a demand for more advanced crawler rigs for all the quarrying carried out.

## What are the components of HPT?

**Edhammer:** The Tunnel Manager PC software for drilling planning, Rig Remote Access (RRA) 2-way communications system linking the rig with the central site control office; Total Station Navigation (TSN) for accurate, fast rig positioning; the Atlas Copco



Bjorn Rosengren



Gunnar Nord

Tunnel Profiler to check the excavation, saving time and money; and Measurement While Drilling (MWD) for a better understanding of the rock mass, all totally integrated with the Rig Control System (RCS).

**Is HPT available on all new models?**

**Edhammer:** HPT is available on all new Atlas Copco computerised rigs, but not direct-control rigs.

**Can it be retrofitted to older models?**

**Edhammer:** It is practical to retrofit HPT systems due to the nature of the modular design of our rigs, and it is quite easy. Where it can be done depends on the facilities but it is possible on site in some circumstances, or in a workshop.

**What are the differences between the three types of Tunnel Manager?**

**Edhammer:** Tunnel Manager is used for creation and handling of drill plans, tunnel lines, laser lines and evaluating round log data. Tunnel Manager Pro is needed to work with Total Station Navigation allowing the integration of 'fix points', Tunnel Profiler data and its own drill-plan generator. Pro can 'look' at MWD data but cannot act on it. For that you need the full Tunnel Manager MWD version.

**When using MWD does the speed of data analysis and transfer to the rig present any potential delays in tunnelling or improve it?**

**Edhammer:** Once the system is set up correctly, as Gunnar Nord will describe, it takes only 5-10 minutes for the RRA to feed back drilling adjustments according to the MWD measurements. So there is no delay in tunnelling.

**Nord:** During the first one or two rounds of a tunnel drive, geologists and rock

mechanics analyse the MWD data and calibrate the Tunnel Manager according to the drilling performance in the rock conditions. The calibration holds true as long as there is no major change in rock type, such as from sedimentary to igneous ground. In such cases recalibration would be necessary. This is an indirect way of evaluating the ground conditions. It can be compared with refraction seismics where the speed and path of induced shock waves through ground are used to evaluate the rock conditions.

The system not only improves tunnelling progress but also prepares the crew for the ground ahead, and to give an estimate of stand-up time before support is required. It could even be linked to NATM etc to assess support needs. MWD was said by the contractor to be very useful in the earlier stages of the Hallandsas Tunnel, with even the rig operator saying it was good knowing what to expect.

**Does HPT lessen the operator skill required?**

**Nord:** As the saying goes, 'A good captain never hurts!' The operator needs to understand what is going on.

**Edhammer:** It gives a new level for the operator to accomplish better precision, but it still needs a skilled operator.

**Nord:** And it always provides recorded data to go back to in case of disputes or just to check what, if anything, went wrong.

**How does the rig sense the data required for further analysis?**

**Edhammer:** The changing ground conditions are indicated using data collected by the computerised Rig Control System. There are eight parameters recorded - for example drill penetration rate, feed force and percussive pressure -



Mathias Edhammer

and these parameters are used to calculate the rock hardness and fracturing index that are used to indicate changes in rock conditions, clay and/or cracking and voids.

**How does Rig Remote Access work, and what are its benefits in comparison, say, to TBM systems?**

**Edhammer:** RRA requires wireless communication on site for the central computer to have on-line access to the rigs in order to get back data files from the rig. The drill pattern is created in Tunnel Manager software by the computer and transmitted to the Rig Control System to be applied immediately by the operator. In this way the site office can have the latest access and transfer data in both directions. The system can also carry information on rig service requirements to predict parts needing replacement, although drill bits, etc are still changed by the operator according to penetration rate reduction.

**Nord:** RRA and Tunnel Manager have their greatest advantage in following an ore body in mining, especially when the face width changes. In construction there is usually less variation in tunnelling unless you change the length of the round for altering ground conditions. The system also allows contour holes to be adjusted for every round to reduce overbreak and underbreak.

**Is there any automatic co-ordination with hole charging?**

**Nord:** Not at present but it is something we are working on. Currently the face team takes into consideration the Tunnel Manager automatic instructions for drill pattern adjustments and charge the holes accordingly.

**With Total Station Navigation (see T&T November 2009 p.32) the accuracy available is now +10mm rather than the previous +100mm. How does this benefit the contractor and operator?**

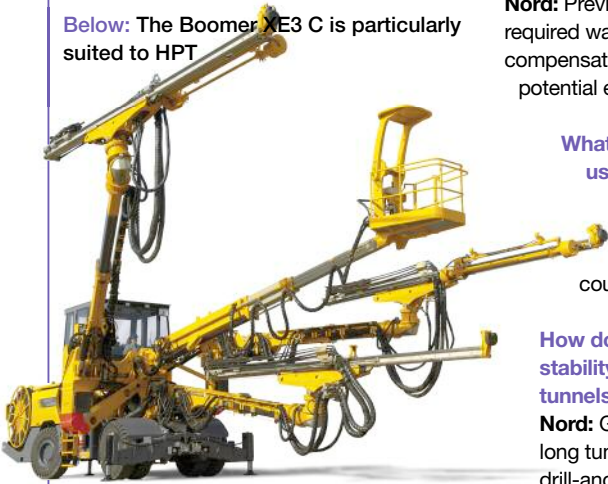
**Edhammer:** The main benefit of TSN is that the operator can now have quick navigation from the cabin to the correct drill position without the need for visits by a surveyor. Using the total station as reference, the rig locates 'fix points' in the tunnel from which it can start drilling in the correct position.

**Nord:** In tunnels the improved accuracy allows you to have as little overbreak as possible without taking more time. There is no time for the operator to locate every single contour hole, and so the revised Tunnel Manager drill plan with accurate positioning from TSN does it for him.

The Tunnel Profiler then checks the

results for under/overbreak and the data used as soon as possible to make any further adjustments to the drill controls, or adjusting with smaller look-out angles or changed collaring position. In extreme cases of overbreak the Tunnel Profiler data can be used to estimate the amount of backfilling required. For efficient tunnelling underbreak must be avoided unless the excess rock can be removed by scaling.

**Below:** The Boomer XE3 C is particularly suited to HPT



**Does the mechanical construction of drillrigs match the levels of precision available with the instrumentation systems?**

**Edhammer:** Compensation for joint movement and boom flexure is built into the Boomer computerised Rig Control System, but the new E-series of rigs have much more rigid booms for more steadiness and accuracy.

**Nord:** Previously the compensation required was much larger, so the less the compensation required, the less is the potential error.

**What types of total station are used in TSN?**

**Edhammer:** We currently use Leica, but any compatible laser theodolite/total station could be used.

**How does HPT affect ground stability, especially in large-section tunnels in competition with TBMs?**

**Nord:** Generally TBMs are favoured for long tunnels of smaller section, with drill-and-blast chiefly for shorter drives

and larger sections. However, it is more difficult to control excavation by TBM compared to the open face of drill-and-blast. With the Pingling tunnels, ground control problems at the face resulted in collapse of the segmental lining, whereas the availability of an open face could have allowed measures to avoid that and improve ground control. Accurate drill-and-blast with HPT also allows partial excavation methods.

**Are there any other important points to make on the use of HPT?**

**Nord:** The improved accuracy is particularly important for road or rail tunnels, and more accuracy produces time savings. I've been on a sewer project in Australia where every contour hole was positioned accurately and painted on the face. It took a very long time but it was worth it because of the savings in concrete. With HPT it is just as accurate but much faster.

**Edhammer:** HPT makes tunnelling a more managed process. Project applications so far include The Northern Link road tunnels in Stockholm and at the Kemi Mine in Finland.

T&T

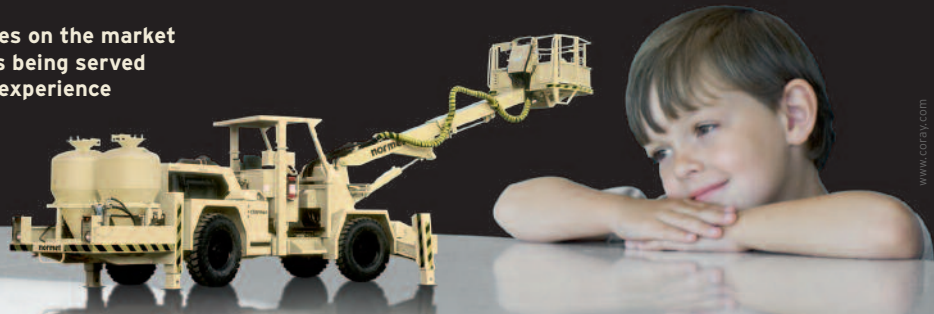


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# Feeling the heat

Tunnelling through a mountain is tricky at the best of times, but when the conditions are arid and your explosives have to be kept under armed guard, things get a whole lot trickier. Emma Gritt reports

**T**he Shis Tunnel links the towns of Diftah and Shis and is part of a larger plan to link the eastern container port of Khor Fakkan to Sharjah City on the west coast of Sharjah, United Arab Emirates (UAE). It is the longest tunnel in the UAE, and also the highest at 575m above sea level. The construction is being overseen by Halcrow Middle East for the Government of Sharjah Directorate of Public Works. It is an international effort, with the design undertaken by Halcrow's specialist hard-rock team based in Melbourne and additional geotechnical input came from Halcrow's Dubai office.

The tunnel is set in a hostile landscape. Not only does it cut through a mountain with a peak reaching almost 900m above sea level, it also traverses wadis - dry riverbeds typical of the area, that are prone to flash flooding during the rainy season.

The twin bore tunnel has a straight horizontal alignment and will hold two 3.65m-wide traffic lanes, 1m-wide hard shoulders and 1m-wide footways upon completion. The tunnel is horseshoe shaped with an arch inner radius of 6.575m. Its vertical alignment is generally 2.0 per cent falling west to east, and a crest curve near the west portal means that there is a high point inside the tunnel. There is a vertical gradient limit to mitigate heavy trucks' exhaust pollution and prevent overheating. It has a traffic headroom envelope of 5.5m, with an allowance for overlaying the pavement.

"The tunnel bores diverge to the east in order to avoid a wadi at the east portal," says Paul Cooper, project manager. "The portal positions are dictated by topography. We followed existing wadis up as high as possible and established portals where cuttings ceased to be economic and where there were suitable faces."



**Above:** Excavation within the NATM was co-ordinated in two stages

**Right:** Halcrow spent nine months reaching the tunnel portal

## Gaining access

Halcrow initially wanted to start works in January 2004 but political difficulties prevented the firm getting on site until December that year. "Although the whole road and tunnel is being paid for by the Sharjah Government, the western half of it is in the emirate of Ras al-Khaimah. This meant that as well as our normal permissions from the Government of Sharjah, we had to go to the Ras al-Khaimah land division," explains Cooper. The firm also needed to be granted permission to establish a compound and that involved dealing with the local wali - a mayor of a small town or village. "There was a lot of toing and froing and liaison," he adds. "We also had to deal with the services authority to make sure there were no objections from the services in order to get permission to construct."

However, these issues did not result in a delay as the contract was not signed with an official start date until the start of works in December 2004. The next challenge Halcrow faced was reaching the site. It took nine months to reach the tunnel portal, which is only 5km from the site office at the western end. "The first couple of kilometers are wide wadi beds which are reasonably horizontal. They are even driveable with a



four wheel drive," says Cooper. "From there it goes up in to a deep, deeply incised valley which has about 45 degree natural rock side slopes going down in to a point, with zero width at the bottom. In order to fit the road up the wadi, putting to one side the change in alignment, we had to fill the wadi and cut the sides away to create a platform wide enough for a dual carriageway." It took several months to create a highway that was wide enough and at a reasonable gradient for delivering machinery to the portal.

Conditions on site were tough. "There's not a breath of wind up there in the

## GEOLOGY

Julian Tyson, engineering geologist on the project elaborates further on the unusual geology of the area: "The tunnel has been blasted through the Hajar mountains near the Oman-UAE border. Here the geology comprises a series of rocks, termed an ophiolite suite, that is composed of oceanic mantle rock that has been pushed up onto the Arabian Plate as a result of tectonic forces. The oceanic crust was formed some 250 to 90 million years ago, after which it was gradually forced up on to the Arabian Plate as this collided with the Eurasian Plate to the east. Normally, these heavy oceanic mantle rocks would have been forced down under the Arabian Plate. However, as a result of the particular conditions at the time of the emplacement (obduction) of the ocean crust in this area, they were actually forced upwards over the lighter continental rocks. A final raising of the ocean rocks to their current position occurred as a result of further compression caused as a result of the opening of the Red Sea to the west some 20 million years ago.

"The rocks exposed at the tunnel are strong, greenish coloured, coarse crystalline, olivine rich gabbro rocks that formed in the mantle at the bottom of the ocean crust. As a result of their unique formation history, this type of rock is rarely exposed anywhere else above sea level on the Earth's surface."

summer. After about April until October, it's a very, very unpleasant place to be outside for any period of time. The rocks will get too hot to touch during the day," says Cooper.

### Tough ground

The geology of the area is as exciting as the challenges faced by Halcrow during the bore. Andrew Crowe, one of Halcrow's engineering geologist says: "The twin-tunnels traverse igneous, ultra-basic peridotites derived from the Upper Mantle which form one of the major geological units of the 'Hajar' or 'hard rock' mountain range. This north-south trending range flanks the east coast of the Emirates and was over-thrust in an east to west direction against the Arabian Shield during the late Cretaceous (120Ma) forming the Oman-UAE Ophiolite Sequence."

Both the olivine-rich peridotite derivatives of 'Harzburgite' and 'Dunite' form the typically dark greenish-grey

rock found within the tunnels. The intact rock is predominantly strong to very strong, fresh to slightly weathered and fine to medium grained.

Discontinuities infilled with hydromagnesite, serpentine, calcite and clay minerals delineate the characteristically blocky to very blocky rock mass. Single and multiple occurrences of weakness zones of up to 300mm thick were encountered during excavation of the twin-alignments. The maximum overburden thickness above the tunnels at the axis of the steep-sided ridge system through which they burrow is 270m.

### Excavation

Works on the tunnels were carried out 24 hours a day in shifts. In order to create the 110m<sup>2</sup> horseshoe-section tunnels, drill and blast excavation using the NATM was co-ordinated into two stages via a top heading and bench sequence. A 7m high arched

opening formed the top heading excavation, which was driven a minimum distance of 150m ahead of the bench. Electronic blasting of the tunnel faces was carried using a classical wedge-cut drill pattern. Emulsion-based Powerdyne cartridge explosives were used in the central and easer sections of the face and 40g PTN-based detonating cord used on the profile holes.

Following each blast cycle, fragmented rock from the front of top heading was removed using a 5t loader and three to four. 20t Volvo dump trucks. This typically took between three and four hours. To date, approximately 250,000m<sup>3</sup> has been excavated. The spoil goes in to general rock fill for the rest of the project. Project manager Cooper explains: "It's good competent rock and the only fill we have for the earthworks on this project is rock."

Geological mapping and rock mass classification using NGI 'Qsystem' was carried out on a round by round basis at the tunnel face after each blasting/mucking cycle. Qsystem also formed the basis for rock support design for each advance of the tunnels using pre-determined classes I-VI for the systematic support of the tunnels. Advance lengths of the top heading face ranged from 1.25-3.5m, again being dictated by rock support class.

Spraying of a primary shotcrete layer provided immediate support of the exposed rock of the arched profile for each incremental advance of the top heading. A remotely operated Meyco Potenza shotcreting unit, capable of spraying 12m<sup>3</sup>/hour was used to apply the fibre-reinforced shotcrete, with accelerator additives applied at the nozzle to ensure early in situ strength of the mix at the tunnel face.

Finally, rockbolting using 4.0m-long full-column resin-anchored rockbolts formed the next stage of installation for the integrated temporary rock support lining. Drilling and spinning installation of the bolt units was carried out by a 2009 model Sandvik DT820 twin-boomed tunnel jumbo, as were the drilling of the blasting holes in the tunnel face.

There is daylight through both tunnels after breakthrough on the eastern side in late 2009 (T&T October 2009, p6). At the west portal looking east, the left tunnel is down to formation level, has had its temporary rock support shotcrete and rock dowels, and is about to be waterproofed and lined. The eastbound tunnel, the tunnel



Left: The twin tunnels are the highest in the UAE at 575m above sea level

**Right:** The travelling formwork for the cast insitu tunnel lining

on the right, is 60-70 per cent down to formation and the remaining is still just on the top heading.

### Handling explosives

Cooper says drill and blast methods were chosen as hard rock tunnelling with a TBM is extremely specialised and suitable machines are scarce. Furthermore, drill and blast is a technique understood by both the client, design team, and the main contractor, General Mechanics, which was responsible for all the tunnel and road works. The only aspects of the project subcontracted to external agents were the reinforced concrete and anything explosive related.

The necessary explosives posed a major issue to the project. "The authorities are very touchy about explosives," says Cooper. "Initially we were having to import them from the Ministry of the Interior in Ras al-Khaimah. It was necessary to plan a blast, order the explosives, transport them to the site under armed guard in a convoy, use them and then burn off anything left. It was forbidden to take any explosives back to the compound."

Later in the project the team were granted permission to build a compound onsite, which streamlined the blasting process and speeded progress. Encased by a large fence and under 24-hour guard from Ras al-Khaimah police, with a network of closed circuit TV and floodlights, the compound allows General Mechanics to get explosives as and when required, and removes the previous need to place orders days in advance.

### Weather or not

When working in the UAE, searing heat is to be expected. However, it was not the only adverse weather condition that Halcrow faced during the project. Seasonal rains proved damaging to progress, as aggressive storms caused havoc on site. "When it rains it really, really throws down. That rain then comes and washes away anything not moved to higher ground," says Cooper.

"The contractor lost compressors and concrete mixers. One memorable time, they had set up reinforcement to do a head wall at the end of one of the culverts. The rain came and swept away and rendered useless about 35t of reinforcement. It just picked it up and threw it down the wadi – it's not just water, it's got rocks in it.

"Rain comes in November to December, followed by another bout around February. What caught the contractor out one year



was that we had a summer storm. You can tell when it's going to rain as the clouds bubble up over the mountains, but the ferocity with which the storm dropped and the amount of water that came down the wadi caught everyone unawares."

Cooper has one recommendation for safety on site during such deluges: "Stay out of the water. It's fast flowing and can be a metre or two metres deep. And it's got rocks and trees and dead sheep and all sorts in it! You really don't want to be in the water when you get a flash flood."

The size of a wadi can vary from a small v-shaped trickle at the top of a mountain to hundreds of metres wide. The Difta portal section is near a wadi that is almost 200m wide.

Despite the threat of flash flooding, and with the exception of relatively minor water inflows (<0.5l/min) occurring after periods of infrequent rainfall, the tunnels have remained dry throughout the excavation period. "We encountered no water at all during the construction period," says Cooper. "We knew the water table tends to be very low, because down at Difta where there is some irrigation, the contractor had to replace some of the wells that were buried by the road embankments. They had to sink wells hundreds of feet into the bottom of the wadi. We were expecting to find perched water tables in the mountains, but in the end we encountered none at all. That was a bit of a surprise."

The project is an exciting one, with many surprises and twists and turns. However, for Cooper, the most dramatic part is the construction itself. He says: "The great drama is having drawn it and looking at the drawings and seeing the size of the earthworks. You go 'wow, that's big earthworks', then you go there for a site visit,

and you see the colossal scale of the road cuttings, and you look up and see 60 or 70m above road level, there is a tiny, tiny little yellow excavator, pecking away at the rockface. That's something I find astounding, that the contractor managed to get someone up there with a machine. I find the ability of people with machines astonishing."

At present there is no electricity supply at the tunnel portal other than what the contractor is generating, but the electricity authority wishes to lay a cable providing 11kv up to the portal. This will provide the power for both the tunnel and the necessary street lighting through a system of transformers and feeder pillars. Cooper adds, "The Electricity Authority has jumped at the idea of a tunnel through the mountain. It means that they can put high voltage through to Shis village."

Shis village will benefit greatly from the new tunnels. At present it is geographically cut off from the rest of Sharjah and can only be accessed by driving through Oman. Not only is the tunnel crucial to the region as Sharjah is the only emirate having access to both the Arabian/Persian Gulf and Gulf of Oman coasts, but upon its completion, scheduled for late 2011 to early 2012, the Diftah-Shis tunnel will reduce the current journey distance between the two locations by approximately 25km.

"The tunnel will mean that Shis can be accessed without leaving the UAE. Occasionally we get locals wanting to use the tunnel as a short cut, so it's a constant battle with the man on the gate who has to explain to them, 'we're blasting, there's rockfall – it's dangerous and you're not authorised on this site', says Cooper. But do they listen? He laughs: "Quite a few have made it through! They just make a run for it."

T&amp;T

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## Expanding Horizons

## Underground

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# Pir Panjal: NATM in the Himalayas

Dr. Friedrich Prinzi, project director for Geoconsult describes how construction of the Pir Panjal Tunnel has had to overcome major difficulties

The Pir Panjal railway tunnel is the first major tunnel in India to be constructed using NATM and has had to overcome labour strikes, equipment failures, horrendous weather and topographical conditions to remain on schedule. Despite drilling and blasting through very heterogeneous rock conditions with frequent changes of mass and fractured rock and with high water inflow the work is progressing without prolonged delays.

The design and construction method is keeping the project on track by allowing fast reaction to varying geology and the installation of initial support measures needed in a young rock mass such as the Himalayas. The tunnel is driven from several faces using drill & blast and road heading with immediate installation of primary support.

About 77 per cent of top heading has been completed. Considering the difficult geology, extreme weather in winter and the



Above: The south portal was excavated in alluvial deposits and slope debris

hostile conditions of the area the overall performance is satisfactory.

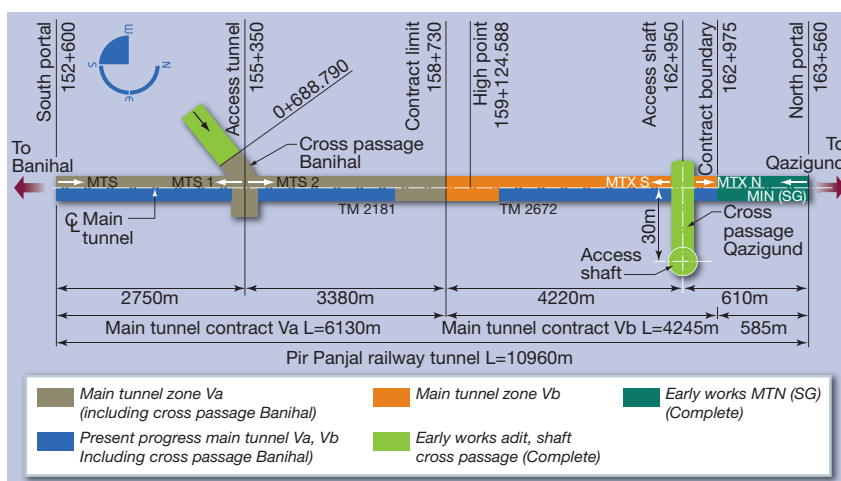
## Railway development

The Pir Panjal Railway Tunnel is part of the New Broad Gauge (1.676m) Railway line of the Jammu-Kashmir Rail Link Project from Udhampur to Srinagar and Baramulla.

The tunnel across the Pir Panjal

mountain range, which forms the border of Jammu and the Kashmir Valley, is one of the key structures of this new line. As a base tunnel between the Banihal valley and the Kashmir Valley it will provide a safe connection throughout the year. After its completion, the tunnel will have a total length of about 11km and will be the longest railway tunnel in India. It is located between the proposed railway stations Banihal (Jammu) in the south and Qazigund (Kashmir) in the north.

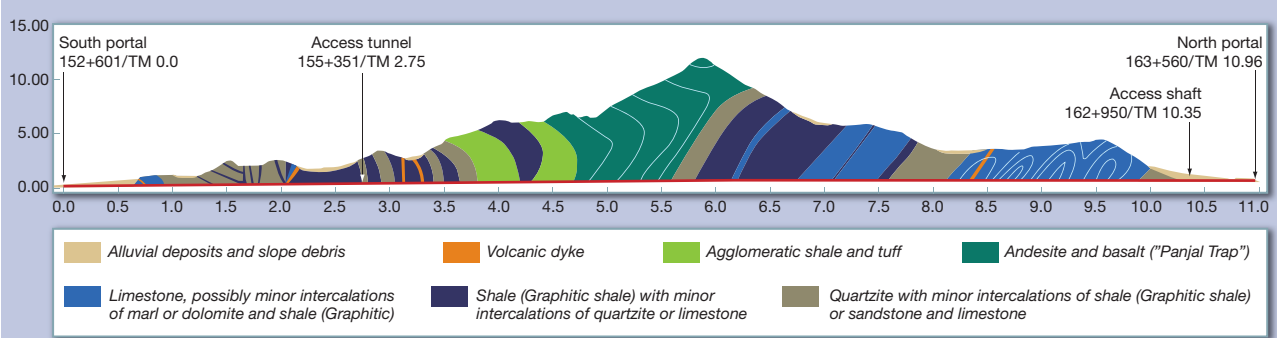
To meet client Northern Rail's standard safety requirements for long tunnels, a 3m wide path will run alongside the single track



Left: Fig 1 – Schematic Layout of Underground Structures

## Who's who

Owner: Northern Railway  
 Client: Ircan International  
 Consultant: Geoconsult - RITES JV  
 Designer: Geoconsult - RITES JV  
 Lead contractor: Hindustan Construction Co



Above: Fig 2 – Longitudinal Section

Left: The north portal with a view of the foothills the tunnel cuts through

for emergency and maintenance access. The main tunnel will be 10960m long. The project includes a 774m long access tunnel (adit) and a 55m deep access shaft with a 30m long connecting cross passage.

**Tunnel design**

The inner tunnel profile was designed to fit a single track railway, an overhead catenary system and the 3m wide access road beside the track. By using an outer (primary) and an inner (secondary) lining with variable thickness depending on the geotechnical conditions, and an invert for soft ground and very poor rock strata, the theoretical excavation section varies between 65m<sup>2</sup> and 80m<sup>2</sup>. Special cross sections are required for the maintenance, equipment and truck turning niches.

The theoretical excavation section of the adit is between 50m<sup>2</sup> and 65m<sup>2</sup>. The inner clearance profile was developed considering movement of heavy construction equipment and use for emergency access during operation.

The excavation diameter of the shaft is 12m, and was developed from the estimated clearance profile with consideration for providing access for heavy construction equipment through the shaft.

Connection structures of the adit and the shaft, which are used for the start of main tunnel driving, are perpendicular to the tunnel axis and have an enlarged cross section. While the width is the same as the adit the roof is about 1m higher than the main tunnel. The maximum theoretical excavation area of this cross passage is about 95m<sup>2</sup>.

The Geoconsult – RITES JV has designed two separate tunnel linings; a primary or outer lining and secondary or inner lining. The primary lining provides safe support during the construction, while the secondary lining will provide support for the

**Geology**

The Geology of the Pir Panjal mountain range includes the complete Cambro-Trias Sequence and includes a mixture of very hard (UCS between 100 and 160 MPa) and moderate-to-hard rock strata (UCS is between 40 and 80 MPa). Hard rock types include andesite / basalt, quartzite, silicified limestone and agglomerates while the moderately hard rock types include limestone, shale, agglomeratic shale and tuff. The cut and cover tunnels and the mined portals are situated in fluvio-glacial sediments (soft ground) which cover both portals and length of more than 500m of the mined tunnel section.

The basic tectonic setting of Pir Panjal range in the area of tunnel alignment is dominated by a folding structure leading to different dipping directions on both sides of the range. The medium steep (60° to 70°) northeast dipping of bedding planes on the southern part becomes steeper towards the main range while on the northern part flat to medium steep (35° to 40°) dipping towards the southwest is dominating. The central areas show a distinct folding. Contact zones between rock units are often faulted. Bedding of rock is striking sub perpendicular to the tunnel axis.

Variable water conditions are expected. Joint aquifers, which will provide continuous water inflow to the tunnel, is expected in the hard rock types with less seepage water in the shale. High water inflow are expected in the fault zones, of which some could be mapped and are predictable. Occurrence of extreme water inflow was expected in karstic limestone on the northern side of the tunnel, but has not been encountered. Particular problems are expected for the shale section at the highest overburden where squeezing rock and large deformations might occur.

lifetime of the tunnel. Thickness and layout of the outer and the inner lining depend on the geotechnical conditions and vary along the tunnel.

### Construction program

The construction sequence was broken into two projects; the early works and the main tunnel works. The early works included the installation of the primary support of the adit, shaft and the 600m long soft ground section from the north portal. The Geoconsult – RITES JV prepared these in separate packages so construction could start ahead of the main tunnel construction. The main tunnel was tendered in two packages, separated in driving from the south portal and adit intersection towards north and driving from the shaft cross passage towards south (see Figure 1).

The use of an interim adit and a shaft has reduced the maximum driving length of the main tunnel to 7600m. In addition the potential risk of delays in the more than 500m long soft ground sections at both portals could be avoided in the critical driving path.

Construction follows a cyclical sequence of excavation and support installation of the outer lining with a delayed installation of the inner lining. For easier control of the water and for a higher advance rate an upward gradient is preferable and was considered in the program in particular where high water inflow was expected.

According to the original program installation of the inner lining should be carried out after completion of driving works in the respective sections. Installation of the inner lining is by casting the invert arch / side beams with in situ concrete and following casting of the crown with in situ concrete using movable shutters. After reconsidering the program inner lining installation is carried out concurrently with tunnel driving.

### Early works

The early works were awarded in July 2004. Site preparation works like access roads, excavation and support installation of portal cuts started in November 2004. The actual driving of the adit and shaft started in May 2005. Driving of the main tunnel from the north portal started in August 2005.

The slow progress experienced in site preparation was due to insufficient planning, lack of winter experience, poor equipment, problems with material supply and severe weather conditions. Security and labour problems aggravated the conditions. Because of the heavy snow fall in the winter of 2004/05 the site was closed for several months. Preparation

works, which were started but not completed before the winter, were destroyed to a great extent. After remobilization of the site repair and rectification of many works were required.

Underground driving started in April and May 2005 at the shaft and the adit, and in August from the north portal. The shaft was completed within four months and the connecting cross passage was finished in March 2006. The construction of the adit needed 23 months which is an average driving rate of about 35 m/month. The main tunnel drive from the north portal required 15 months which is about 42m/month.

Both drives of the early works encountered difficult geotechnical conditions. The main tunnel from the north was in soft ground over its total length and round length was limited to 1m. After a learning period of two to three months top heading driving speed increased to 50 - 60m per month, which is about two rounds per day. During the winter period 2005/06 construction came to a complete stand still and started again slowly before increasing the progress to an average of more than 90m per month or three or more rounds per day.

The adit was driven in soft ground for about 30m and subsequently in shale and quartzite. Very weak and good rock conditions changed frequently and several fault zones with crushed material and heavy water inflow were encountered. The conditions were aggravated by the 10 per cent down gradient requiring continuous dewatering. After a learning period with slow progress of almost a year average driving rates of 50 - 80 m/month and peak rates over 100m/month could be achieved over the summer season from May to November, while the progress at the start of the works and during winter was extremely slow with frequent stops.

Reasons for the slow progress can be summarised as follows:

- In generally difficult geological conditions combined with no experience by the contractor of the construction method and long learning period.
- Poor quality of the equipment and poor maintenance. Because of the small contract values only old equipment was used.
- Accordingly frequent breakdowns common and performance in drilling, blasting, shotcrete spraying and installation of other support measures were slow.
- Insufficient and inadequate tools.
- Lack of tool kit for emergency situations
- Poor drilling performance and inadequate

### Primary lining

The task of the geotechnical design, besides consideration of economic aspects, safety during construction, stability, and environmental aspects, is the fast installation of the support measures and the easy adaptation of the excavation method and support measures in accordance with the actual geotechnical conditions. This is particularly important for heterogeneous rock conditions with frequent changes over short distances.

From the evaluation of the geotechnical conditions and different rock mass types, possible rock mass behaviour types were deferred by also considering the overburden (primary stress conditions), rock structure (strength, type and properties of discontinuities, fault zones), hydraulic properties and conditions, and size and location of the tunnel. From the assessed rock mass behaviour in a total of eight different excavation/support classes are used; two for soft ground and six for rock strata.

Typical support measures include shotcrete, lattice girder, wire mesh and rock bolts. Special measures include pipe roofing, forepoling, face sealing and face bolting. For control of water inflow, drainage measures are to be considered using long advance drainage holes or pipes. Grouting would be used for filling overbreak and cavities. For stabilisation of rolling ground and control of water inflow grouting may be applied in particular cases.

As a particular case rock squeezing is considered for the highest overburden and shale strata of low strength. As a standard measure longitudinal slots of defined width will be left in the shotcrete lining, so shotcrete can deform by gradually reducing the slot width without breaking and spalling. For control of the deformation additional support with deformable steel struts (yielding elements) will be installed in the open slots. Such yielding elements are steel cylinders or folded steel sheets with slots. The strength of the yielding elements will increase with deformation, but will be less than the shotcrete strength.

The support is generally slim and of light weight and can be easily and quickly adjusted to the actual conditions. In comparison, the standard Indian design of D-shape or horse shoe section and heavy steel support do not allow quick installation and changes in case of very weak rock conditions and short stand up time.

blasting technology. Low quality of electric detonators.

- Problems with dewatering in case of high water inrush and downward drive due to lack of standby pumps, cable extension and power.
- Severe weather conditions combined with poor maintenance of construction site

(construction road) and inexperience with such conditions.

- Blockage of the highway from Jammu to Srinagar by landslides during bad weather conditions and associated problems with supply of construction material and spare parts combined with inadequate planning for supply of construction material and spare parts.
- Road closure in winter and interruption of connection between construction sites in north and south.
- Non availability and/or poor performance of communication facilities (telephone, fax, internet, cell phones).
- Hostile conditions and security problems in Kashmir area.
- Labour strike and labour unrest

### The main tunnel

The main tunnel drive from the south portal started in April 2006 after five month of site preparation including portal cutting and installation of slope support. In July 2009 the main tunnel drive from the south portal reached the counter drive which was excavated from the adit at tunnel meter 1961.5. The top header drive has an average driving rate of 50m per month. Encountered geology included about 550m of soft ground, followed by about 390m of highly weathered and fractured limestone with sandstone intercalations, bands of quartzite with thick clay fillings and volcanic dyke, followed by some 1020m of very strong slightly fractured and weathered quartzite with clay and shale intercalations. All ranges from wet to dripping and flowing water were encountered in the rock with water inflow up to 10l/sec.

A counter drive was started from the adit towards the south in September 2007. In June 2009 the face was stopped for the breakthrough at tunnel meter 788.5. This drive has an average progress rate of 36 m per month. The slower rate is due to the fact that this drive, which was not on a critical path, has not been continuously driven.

Encountered rock for the first 380m was mainly shale with quartzite bands during the first 80m. Shale was highly to moderately fractured. The encountered rock for the next 100m was shale and limestone and changed completely for about a further 80m to limestone, followed by argillaceous limestone for about 70m. The argillaceous limestone was highly to moderately unweathered with sheared rock mass and with volcanic Dyke/Sill. The following about 160m of the encountered rock was grey quartzite alternating with a band of black shale. Quartzite was very strong to strong, unweathered and highly to moderately fractured. Water conditions were dripping with local flowing.

After completion of the adit another drive towards the north could be started in March 2007. In early December 2009, 2210m of header drive were completed, which is an average driving rate of 67m/month. Encountered rocks included about 320m quartzite and shale layers of varying thickness between 10m and 40m, followed by shale with quartzite bands for about 260m, and quartzite and fault breccia for about 70m, grained quartzite with shale bands and breccia for about 480m. Quartzite was highly fractured and water ingress was high. In general water flow was between 20l/sec and 60l/sec. The highest water inflow was 160l/sec. Further encountered rock was agglomeratic shale for about 700m, followed by green andesite with quartz as inclusion and with locally weak zones. The agglomeratic shale was moderately laminated, fractured and fine grained with a water flow from damp to seeping. The andesite was very strong unweathered and blocky with a water flow from dry to dripping.

After completion of the shaft cross passage and preparation for driving, excavation of the main tunnel towards the south started in July 2006. For about six months, until full completion and handover of soft ground section of the main tunnel north, the shaft was used for material and equipment supply and muck removal. By early December 2009, 2670m of heading drive was completed which gave an average progress rate of 65m/month. Encountered rock was very weak and highly weathered shale for about 50m, highly fractured quartzite with shale intercalations and frequent shear zones for about 150m, weathered limestone with frequent shear zones for about 80m, quartzite with shale bands for about 100m and from about tunnel meter 390 for about 1860m limestone of varying degree of weathering with shale intercalations and occasional shear zones. Karstic features were expected

for this limestone section, but besides clay coating and clay filling in the joints and fractured rock in some areas only minor karst features were found. The further rock encountered from tunnel metre 2245 was quartzite with shale and limestone intercalation, gauge material, clay filling and shear planes. The encountered quartzite was strong to weak, slightly to highly weathered, fine grained, highly fractured and bedded. Water conditions were generally from wet to seepage flow of several litres per second. Maximum water inflow was in the order of 50 and 60l /sec.

In comparison to the early works construction progress has increased in all drives, which is mainly due to improvement of the main construction equipment and provision of tools and tool kit which allows faster reaction and control in case of changing rock conditions. Provision of new construction equipment included Boomer drillrig, heavy tunnel excavator with movable head in all direction, a large loader with side tipping shovel for unloading, and robotic nozzle for shotcrete spraying.

However, idling periods and stand stills are still on the high side, because of break down, missing spare parts and frequent tire failure. A major impact to works can also be attributed again to severe weather conditions, the hostile situation of the work site, labour strikes and similar conditions which are outside of the control of the contractor and Ircon.

### Outlook

More than 9200m (about 77 per cent) of underground driving of the Pir Panjal tunnel is complete. More than 8200m or almost 75 per cent of the main tunnel heading drive has been finished. For the tunnel section between adit and shaft, which is on the critical path, about 4900m are driven and about 2700m are still remaining. From recent progress rates the final break through could be possible in early 2011.

Uncertainties remain with regard to the security situation in Kashmir and associated interruption of the work. Other uncertainties are related to rock mass conditions in fault zones and at the higher overburden. Present overburden is close to 600m at the south drive and about 440m at the north drive. Particular uncertainty is related to the highest overburden of more than 1000m and in the shale, where squeezing rock conditions may occur. It is fair to say that under the given conditions at the work site and in comparison to other tunnels of the Jammu-Kashmir-Railway project Pir Panjal Tunnel achieved a good overall progress and work standard. T&T

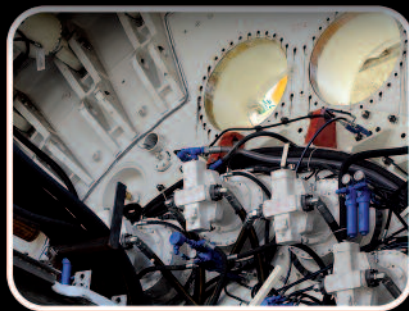
## REFERENCES

- 1 Austrian Society of Geomechanics, Division "Tunnelling", Working Group "Conventional Tunnelling": Conventional Tunnelling "The Austrian Draft",
- 2 OENORM B2203-1: Construction of Underground Works – Standard for Work Contract, Part 1 Cyclical Excavation
- 3 G.Feder: Mechanics of Rock Masses near the Excavation Face of Tunnels with high Overburden (1976)
- 4 ITASCA: FLAC 5.0, Finite Difference Analysis Software

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# Letters

Dear Sir,

I recently came across a letter of mine that was published in the trade press back in 2001.

Unfortunately in lots of ways as far as specialist subcontractors are concerned nothing much has changed in the meantime!

With one important distinction—the risk is now even higher! Unfortunately for specialist subcontractors in the current economic climate the risk is even higher because they cannot be certain that the company holding on to their money is going to be around to pay out when the time comes.

With the construction industry suffering in the current economy it is the subcontractors who are taking the brunt of it, and abuse by main is set to get a whole lot worse.

There are lots of contractors out there who have won work at negative margins and when those chickens come home to roost they will be doing their utmost to find a profit from somewhere.

And that can mean only one thing – the subcontractors will be right in the firing line! The point is subcontractors still need to be especially vigilant about the terms of the contracts they are entering into even if they are desperate for the work!

For instance, as the UK law stands, contractors can still get away with adjudication clauses that effectively

take away their subcontractor's right to adjudication by making them responsible for all the costs!

Compare these two true scenarios that I have been involved with over the past couple of weeks:

Client A is owed several thousand pounds. The contractor refuses to value his account properly and is hiding behind the firm of quantity surveyors he has employed to act as his bullyboy (also known as surveyor). Trust me, I know the guy involved and when it comes to arrogant, ignorant bullyboys, they don't come much more arrogant or ignorant!

Unfortunately, client A's contract has an "if you adjudicate you bear all the costs" clause. So the only sensible option is litigation.

Litigation may ultimately not cost that much more than adjudication, but it will certainly take a lot longer. In the meantime the contractor gets to keep the money and can afford to sit back and wait to see what happens!

Client B was owed several thousand pounds in retention. The contractor was giving my client the usual "no Certificate of Making Good Defects excuse."

This is probably excuse number one in the "Contractors Non Payment of Retention Handbook".

My client had established that the reason that the Certificate hadn't been issued had nothing whatsoever to do with his works. There was no bar to us adjudicating. So we wrote to the contractor and pointed out the error of his ways and asked him to pay up.

For reasons that I won't go into here, on my advice, my client also sent letters to the directors' home addresses! My client got paid in full.

The point of recounting these true stories to you is this:

Please, please, please, please, please don't sign up to "adjudicate and pay all the costs" type clauses or any other onerous terms for that matter!

If you challenge them, most if not

all contractors, will accept that they are trying it on and agree to change onerous provisions.

If they won't – what does that tell you about who you are thinking of contracting with? What does the fact they tried it on in the first place tell you about them? To quote an old adage "If you don't ask you don't get!". So ask for fair and reasonable terms.

Specialist subcontractors often complain that they don't know who to turn to for advice and that there is nothing they can do to improve their position but in my experience that's just not the case.

There are lots of things they can do and one essential resource that provides information and advice that applies to all specialist subcontractors in the construction and engineering industries can be found at: [www.streetwisesubbie.com](http://www.streetwisesubbie.com)

This is something completely different from the service you may already be getting from your trade association and provides free access to a panel of no fewer than 14 leading industry experts! And with information on over 40 different aspects of your specialist subcontracting business it is a great place to start.

You never know it might just protect you from what is lurking around the corner!

**Barry J Ashmore**  
*Ashmore Consulting*

Dear Sir,

Regarding the article titled "LaserShell paper on the mark" printed in the December 2009 edition of T&TI, I would like to clarify two points.

Firstly, the ICE Telford Premium Award 2009 was not just given to me but also to the paper's co-authors Alun Thomas, Yu Sheng Hsu and Matous Hilar and the work presented in the paper was undertaken while all the authors were employed by Mott MacDonald on the Terminal 5 project. Mott MacDonald was tasked with evaluating the LaserShell method on behalf of the client BAA.

Secondly, it should be made clear that the LaserShell method was developed jointly by Beton- und Monierbau (BeMo) and Morgan Est.

**Benoit Jones**  
*Morgan Est*

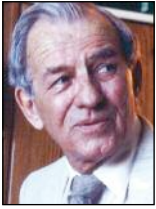
## ANY COMMENTS?

**If you have a comment or anything you'd like to put to the industry we'd like to hear from you. Please contact the editor by post, email, fax or through our web site:**

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# Obituary

## Edward Graf



The grouting industry has just lost another "Grouting Great." Edward Dutton Graf, a pioneer in grouting and foundation engineering, passed away of lung disease on

December 16, 2009 at Kaiser Hospital in Honolulu, Hawaii. He was just two weeks shy of his 85th birthday.

A native Californian, Ed Graf was a World War II navy veteran, engineer, contractor, inventor, consultant and pilot.

Born December 31, 1924, Ed spent his early childhood on a farm in the Imperial Valley and later moved to Los Angeles. He graduated from Washington High School at age 16 in 1941. He was studying business and engineering at UCLA when World War II began. His NROTC training was accelerated, and he commissioned as an Ensign 2 years later and went to sea. Ed was assigned to the Navy's "Splinter Fleet" as an officer on a wooden hulled sub chaser. More than 400 such ships were built quickly to counter the

threat of enemy submarines in the Atlantic and Pacific war theaters.

The sub chaser was the smallest commissioned ship in the Navy. Ed was assigned to SC 732 and reported for duty at Langemak Bay, New Guinea on July 8, 1944 as an Engineering Officer. In later years, he would proudly recall "serving on a wooden ship with iron men."

On September 20, 1945, at the age of 20, Ed took over as 'skipper' of SC 732 where he continued in that role until 1946 when she was decommissioned and turned over to the Philippine Government.

Following World War II, Ed returned to civilian life, completing his engineering degree at UCLA in 1948. He went to work for Bechtel, where he supervised his first grouting job in 1952. He then worked briefly for a Gunitite contractor supervising all grouting operations. In 1957, Ed decided to go out on his own and formed Pressure Grout Company. Over the next 31 years as owner of Pressure Grout, Ed was involved in soil stabilization and underground water shutoff projects for building and civil projects in many parts of the world.

Over the course of his career, Ed pioneered

the development and use of several grouting techniques, including compaction grouting (for which he wrote the first paper describing and naming it), chemical grouting, and controlled fracture grouting (also known as Lense grouting). He was inventor and co-inventor of six issued patents for pressure grouting. After nearly 30 years of being in business, Ed sold his company to enjoy retirement, first in California and for the last 11 1/2 years in Hawaii.

He was an annual Geotechnical Engineering lecturer at the University of California, Berkeley, and Stanford University, and at numerous engineering seminars and engineering society meetings.

His grouting consultant work involved projects throughout the U.S. and overseas.

Ed was very proud of his service to his country and to the grouting industry. According to his daughter, Teri Graf-Pulvino, he lived his life by his own rules. In his later years he said often: "I am the luckiest guy on the planet," and was very thankful for his life as it turned out.

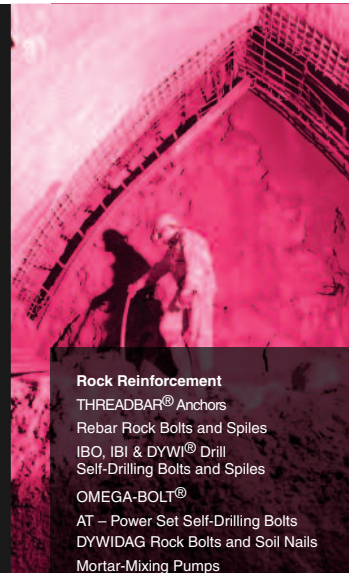
In addition to his daughter Teri, Ed is survived by sons Tom and Eric Graf and four granddaughters.

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# Products

## Light demolition

Equipment manufacturer Conjet AB last month launched a lightweight hydro-demolition unit that can be mounted on standard scaffolding. The firm claimed the Nalta Jetframe 101 is the world's smallest and lightest hydro-demolition unit.

Nalta is primarily intended for the hydro-demolition of concrete, but is also suitable for other applications, such as cleaning and de-scaling of steel. A different power head with a self-driven rotor is available as an option that can be used for numerous surface preparation tasks.

The equipment replaces and

automates the dangerous and far less productive hand lancing method of hydro-demolition, as the Nalta operator remotely controls all functions from a safe distance.

According to a Conjet AB spokesman, "The unit is flexible and versatile as it mounts, climbs and operates on standard scaffold tubes, and as there are no electrical sensors it can also operate under water. All components are small, light, easy to carry and position."

Nalta should eliminate the accidents that can occur with the hazardous hand lancing operations and has proved more

productive in pre-launch contract trials. "We are replacing the dangerous hand held lancing operations and making them safer," said Conjet vice president Lars-Göran Nilsson.

"Contractors that have so far used the 'Nalta', during on site contract trials, have been very impressed with its safety and performance. With a hand lance pump of 120kW, generating 250N reaction force, production will be between two to three times higher than with a hand lance," said Nilsson.

"Because Nalta can withstand a greater reaction force of 600N, compared to 250N for a hand held lance, higher powered pumps can be used, increasing productivity even further up to five to six times," claimed Nilsson. He added "Nalta is also very easy and quick to set up and can work continuously, so there is far less downtime compared to hand lancing, where operators have to stop and rest every 20 minutes or so."

The cutting head weighs 14kg, the feed beam section 6kg and each hydraulically controlled step units, which are fixed to each end of the feed beam and automatically climb up and down standard scaffold tubes, weigh 9kg. The trolley mounted hydraulic control unit weighs 90kg.

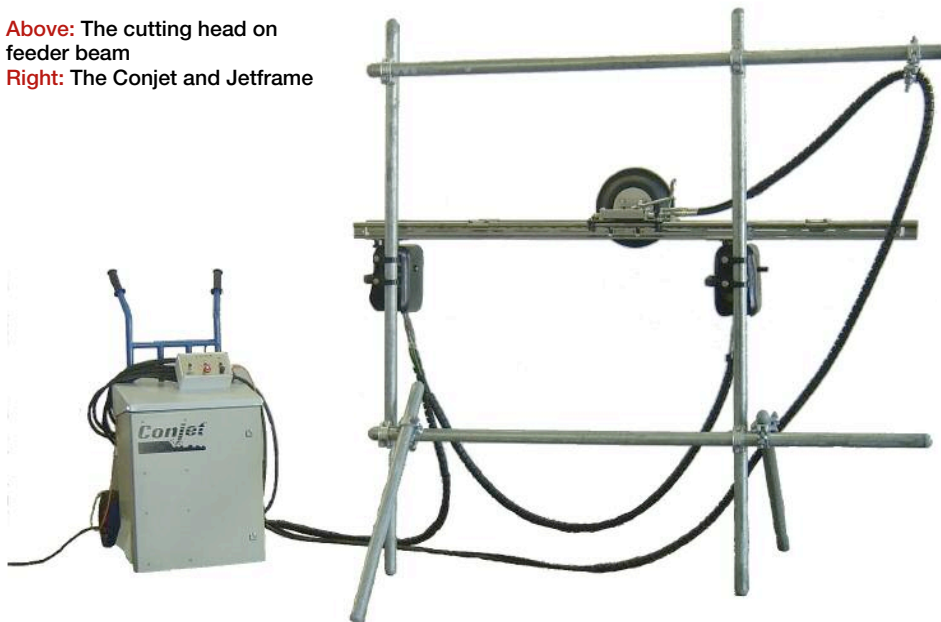
**Conjet AB**

**Web:** [www.conjet.com](http://www.conjet.com)



**Above:** The cutting head on feeder beam

**Right:** The Conjet and Jetframe



## Firm grip



An innovative range of access covers that significantly reduces the risk of skidding and skid-related road accidents has been recognised with an international road safety award.

The GripTop range, produced by iron technology firm Saint-Gobain PAM UK, won the Motorcycle Award category at the 2009 Prince Michael International Road Safety Awards.

Daniel Débois, head of marketing for access covers and gratings at Saint-Gobain PAM UK, received the award from HRH Prince Michael of Kent, along with Mike Harper of the company's technology partner Stirling Lloyd, and Mike Brewer and Terry Bullock of Bristol City Council, which has extensively trialled the GripTop product in Bristol city centre for three years.

Prince Michael said: "All too often the blame for accidents is put on motorcycle riders – here we see a really clever road engineering invention which will make a real difference to riders' stability."

GripTop was developed as a response to the problem of traditional metal access covers which become worn smooth over the decades and can present a major significant skidding hazard for two-wheeled road users, especially in wet conditions and in locations where sudden or harsh braking may be required.

The product features an aggregate surface bonded to the iron which offers an average skid resistance value of 65 to 70, matching the skid resistance required for high risk road sites. It is available in several colours of aggregates to match surrounding road surfaces.

**Saint Gobain PAM UK**

**Web:**

[www.saint-gobain-pam.co.uk](http://www.saint-gobain-pam.co.uk)

# Products

## Latest in lasers

Australian laser designer and manufacturer MCE Lasers last month launched an intrinsically safe tunnelling laser. The LD.60.IS laser allows accurate construction and alignment of tunnels driven by TBMs, drill and blast, pipe jack or conventional hand techniques.

According to MCE, the LS.60.IS does not require explosion-proof casing, and is intrinsically safe to work in gaseous environments such as methane and air mixtures,

according to AS/NZS 60079.0:2000 and AS/NZS 60079.1:2000 standards. The unit is waterproof, rugged and entirely constructed of stainless steel and brass. The laser is based on diode technology and powered by 4 'D' cell batteries, with an operating time of 300 hours.

When used with an adjustable gimbal, the laser is easy to install on tunnel walls and to adjust to target.

MCE specialises in the manufacture and design of lasers



Above: The LD.60.IS laser

for alignment and levelling. Other lasers used in tunnelling include the LD.60x25 long range laser with focusable green or red beam and

single and dual beam lasers.

**MCE Lasers**

**Web:** www.mcelasers.com.au

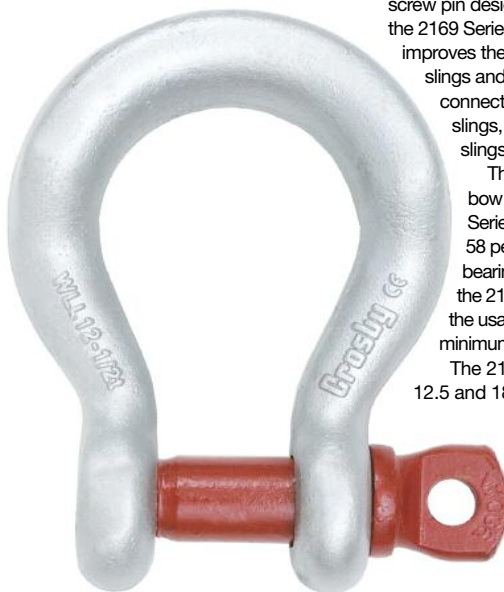
## Shackle launch

Accessories manufacturer The Crosby Group last month launched the forged alloy steel 2169

Series shackles. The 2169 Series have the same attributes as earlier 2160 wide body shackles but with a screw pin design. Crosby claimed the 2169 Series significantly improves the life of wire rope slings and can be used to connect high strength round slings, synthetic round slings and wire rope slings.

The increase in shackle bow radius of the 2169 Series provides minimum 58 per cent gain in sling bearing surface. In addition, the 2169 Series increases the usable sling strength a minimum of 15 per cent.

The 2169 is available in 7, 12.5 and 18t capacities and in a galvanized or self coloured finish.



**The Crosby Group**

**Web:** www.thecrosby-group.com.

## Squeaky clean

Swiss firm BASF Construction Chemicals has launched a new TBM tail sealant it claimed is more eco friendly. The MEYCO TSG 26 is a specially developed tail sealant with low ecological impact designed for open mode EPBMs and hard rock TBMs, according to a BASF spokeswoman.

The spokeswoman added, "In contrast to currently used tail sealant greases, TSG 26 is 100 per cent oil free, contains mainly natural products and is

completely inflammable."

Together with TSG 6, TSG 26 rounds up the portfolio of BASF specialty chemicals for TBMs:

- SLF and RHEOSOIL soil conditioning agents and polymers
- ABR anti-dust and anti-abrasion agents
- BSG bearing sealing greases
- EPB bearing lubrication greases
- GA admixtures for annulus grouts

**BASF Construction Chemicals**

**Web:** www.basf.com

## Rock drilling demo

The screenshot shows the Rockmore International website. The main navigation bar includes Home, About, Applications, Products, Events, Newsroom, and Contact. A sidebar on the left lists various applications: Mining, Tunneling, Construction, Quarry Aggregate, Water Well, DTH, Extension, Drilling & Tunneling, Tapered & H-Thread, Integral, Shank Adapters, and Shank Adapters Technology. The main content area features a large image of a drilling rig with the word 'productivity' overlaid. Below this, there is a section titled 'Introducing the New XR32 Thread Design for Drilling and Tunneling Operations' which describes the benefits of the XR32 thread system, including higher bit penetration rates and longer thread life. A sub-section titled 'MultiPoint - The Next Generation of Carbide Inserts for Button Bits' describes the benefits of the MultiPoint carbide insert design, such as increased penetration rates and longer insert life. The website also includes a 'Download our full PRODUCT CATALOGUE here' link and a 'How can we better serve you?' section with a link to an 'ONLINE SURVEY'.

Drilling tools manufacturer Rockmore International has bolstered its online specification offer with the launch of its new website. The site features 3D animation of the latest rock bit introductions including the DTH drilling hammer, Rockmore's new MultiPoint carbide insert design, the innovative XR32 thread design, and SonicFlow.

Online specifications include details on threaded and tapered drill bits, DTH bits and hammers, extension and tunnelling rods, integral and tapered rods, shank adapters and other drill tool accessories.

Quick access to product information is also available with download versions of Rockmore's new

product catalogue, the DTH Hammer Operations Guide, DTH Hammer Performance Summary, and technical data sheets for all of Rockmore's ROK Series DTH Hammers.

An interactive online survey provides continuous input for the needs and requirements of operators and contractors working in the field. Collected data is then used in the development of products and services.

Rockmore International is a global manufacturer of rock-drilling tools, serving the mining, construction, and water-well sectors.

**Rockmore International**

**Web:** www.rockmore-intl.com

# 'No-Dig' techniques continue to advance

The push for greener technology and less intrusive utilities repairs are driving the need for development in trenchless techniques. Ian Clarke looks at how the industry is responding to this demand

**F**or the past four decades trenchless technology and its forerunners have found increasing acceptance across all the major underground pipe industries.

Increasing calls for environmental protection, reduction of social impact of construction works, the effects of climate change (flooding etc) and increasing focus on the carbon footprint of construction works mean that the various benefits of trenchless methods are becoming increasingly sought after.

## Environmental needs

Work carried out at Waterloo University in Canada has estimated the greenhouse gas (GHG) production for open-cut and trenchless methods. The results of the work have shown very significant savings in GHGs when using trenchless technology with over 90 per cent less GHG production in some circumstances. The Waterloo University work has also led to the development of a 'Carbon Footprint Calculator' which gives engineers the facility to estimate the GHG output of a project. The calculator can be found at: <http://www.nastt-bc.org/carboncalculator/nastt00.php>

**Below:** Bohrtec's new Front Steer auger boring system

Other environmental issues of relevance to trenchless technology include increasing public awareness of the effects of road works on their daily lives and businesses, and the recent floods with questions about land drainage and other storm water handling systems being 'fit for purpose'. Trenchless systems are therefore finding significant favour amongst utility owners, the Environment and Highways Agencies (in the UK) and local government offices, where they are practical to apply.

In the UK the introduction of permit systems for in-road operations in some cities to try to ease congestion, the spectre of lane rentals (Clause 74) and the move to place what is expected to be over 200,000km of currently private drains and sewers into the hands of the main water companies in April 2011 is likely to have an effect on how trenchless technologies are viewed.

## Jacked pipes

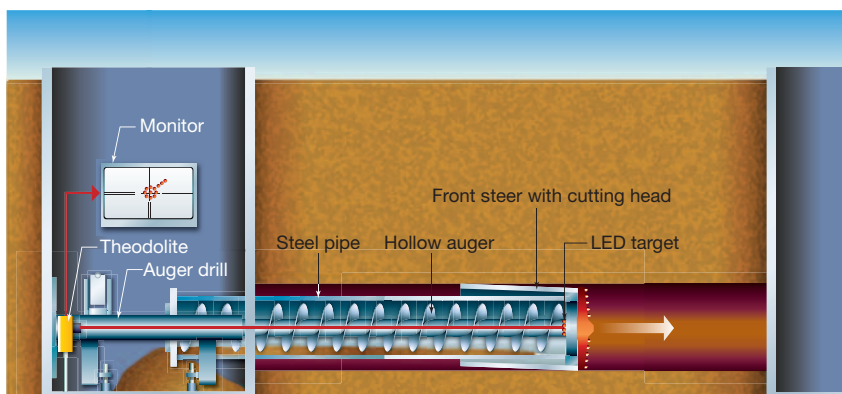
Whilst governments and associated bodies look at the environmental and political aspects and responsibilities of the utility and infrastructure industries, manufacturers and contractors have continued research and development to improve and expand the techniques available to them. This includes new equipment and the application of new and existing systems to

practical problems faced every day across the industry.

Herrenknecht's subsidiary Bohrtec has introduced a novel steering technology to extend the application range of guided auger boring. Instead of using conventional ground displacing pilot drilling technology which cannot be used in dense soil or rock, the new patented steering technology, called 'Front Steer', overcomes the usual application restrictions and enables work in very dense strata (Standard Penetration Test - SPT values >35) and in moderately strong rock (strengths up to 20Mpa). This is done using a guided-head auger-borer system that excavates the ground as it advances. The development does not lose the economic advantages of guided auger boring using pilot rods because the guided auger boring system with Front Steer retains the advantages of quick and easy set-up of the equipment on site and simple operation.

McLaughlin of the US has introduced the CBM 48 cradle earth-boring machine designed to help speed the installation of steel casing used in the cross-country pipelines. First used in the USA in the 1960s and '70s as a means to install longer sections of pipeline casing in a more time efficient manner, McLaughlin has re-engineered this proven technique to include state-of-the-art safety and control features. The cradle boring method saves pipeline contractors time because it is not necessary to set up from a construction pit, which is often necessary with conventional auger boring. A trench the length of the casing is excavated and the cradle boring machine along with the casing are suspended in the trench using pipe-laying or side-boom equipment.

Akkerman, a specialist in microtunnellers, guided boring machines and pipe jacking systems has introduced the Pilot Tube Microtunnelling system (PTMT). The difference between standard pilot auger boring system and the new PTMT is that,





**Above:** The CBM 48 cradle earth boring system from McLaughlin

subsequent to the installation of the guided pilot bore and an initial expansion of the bore diameter with a reaming head and auger chain, the final ream to the pipe diameter and installation of the jacking pipe is achieved using a powered microtunnel cutter head. The PTMT system is designed for use by contractors installing pipe in diameters of 500-1200mm o.d. It operates in a 3-pass process installing first the pilot tubes followed by the use of temporary casings and augers to increase the bore diameter and finally using the powered cutter head behind the temporary casings and reversing the auger flow toward the reception shaft. Subsequently the product pipe is jacked into the bore.

### HDD developments

Various new horizontal directional drilling (HDD) rigs have been introduced recently.

Vermeer has expanded its line of Navigator horizontal directional drills with the three maxi-size units: the D500x500, the D750x900 and the D1000x900, all for large diameter pipes. Based on Horizontal Rig & Equipment (HRE) designs, acquired in 2008 by Vermeer, the three drills feature respective pullback forces of 500,000lb, (225,000kg), 750,000lb (337,500kg) and 1000,000lb (450,000kg).

Vermeer has also introduced the D9x13 Series II Navigator horizontal directional drill designed for confined jobsites and areas where surface disturbance to turf, such as residential and commercial lawns, is a

concern. The newly introduced compact model will be especially useful for fibre-to-the-home and other utility installations. The new D9x13 is designed to accommodate over 90m of drill rod for longer bores and has a 2-speed rotation gearbox to enhance controllability, allowing the operator to increase backreaming speed when conditions allow.

For very accurate boring requirements, the Axis guided boring system from Vermeer is a pit-launched, laser-guided tool

to install 10-14in. (254-356mm) diameter pipe. The system can achieve pinpoint accuracy and its versatile design allows for multiple applications in the installation of new water and sewer pipelines.

Ditch Witch also announced the release of what is claimed to be its most powerful directional drill to date, the JT100 Mach 1. Equipped with a 200kW engine, the JT100 is designed for rotation, thrust, and drilling fluid flow to operate simultaneously at full power, which leads to faster job completion. With 445kN 100,000lbf (445kN) of pullback and 12,000 ftlbf (16,270Nm) of torque, the JT100 is built for both long-range bores, such as river crossings, and installation of large diameter pipe. An onboard crane is used to load and unload pipe boxes, anchor the unit, and handle downhole tools. An optional feature is an onboard anchor system, exclusive to Ditch Witch, which stabilises the machine on virtually any terrain.

As for support equipment for HDD the DCI DigiTrak F2 delivers the most popular features of the Eclipse locator with enhanced sensitivity and greater ease of operation. The DigiTrak F2 incorporates DCI's patented 3D antenna and 'target-in-the-box' locating with a new depth screen display for high accuracy and clarity. A 2-dimensional bird's eye perspective is viewed on the same screen as the depth view. This means for the first time with an HDD locating device it is possible to actually view the drill head location in 3 dimensions in real-time. The data display screen is streamlined to provide transmitter

**Below:** The D1000x900 Navigator is Vermeer's largest HDD rig



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**Left:** The powerful JT100 Mach 1 HDD rig from Ditch Witch; **Right:** The DCI DigiTrak F2 is a popular support for HDD rigs



conventional rehabilitation product combinations. The product, due to the reinforcement with carbon and/or glass fibres, provides a structural solution that is approximately 50 per cent of the thickness of traditional pipe liners to maximise pipeline capacity after lining. The new liner's reinforcement fibres are also resistant to the corrosive materials and conditions found in sewers.

Insituform also claims that iPlus uses less resin than traditional products, less energy to cure the product, less fuel in factory-to-site transport and can be installed in less time than conventional cast-in-place pipe (CIPP), so saving energy and reducing emissions across the lining process. iPlus composite liners have a polypropylene coating on the inner surface increasing the pipe's smoothness, reducing surface friction and providing an additional corrosion barrier.

roll, pitch, signal strength and temperature in a single column view.

### Pipe replacement

Pipe replacement techniques have become increasingly popular over the past decade, but one of the questions asked by many end users has been 'How will the broken shards inter-react with the new pipe as it gets pulled in?' In some cases shards have caused the new pipe to be damaged during installation. This has led to deliberate over-engineering of the new pipe to make allowances for damage, or the use of over-sized bore expanders to maximise the void into which the new pipe is pulled.

Perforator of Germany, along with its UK subsidiary of Sheffield, has introduced bursting rigs designed to overcome this problem, including the RBZ60 with a pullback capacity.

Working in exactly the same way as traditional hydraulic rod-based pipe bursting systems, the major difference between the new rigs and the old style is that, using an independent grout injection system, a cement grout mix is pumped through a feed line running inside the new replacement pipe. The grout is extruded under pressure via ports in the expansion head that are positioned to ensure that the grout is uniformly placed around the new pipe as it is pulled in. The grout combines with the old pipe shards and the mix is pushed into the surrounding ground, cementing the shards into place so avoiding pipe/shard interaction and eliminating the need for over-engineering.

### Renovation developments

Pipe renovation has been around for over 30 years, but some of the latest developments have been designed to overcome difficulties experienced with some of the more traditional lining systems.

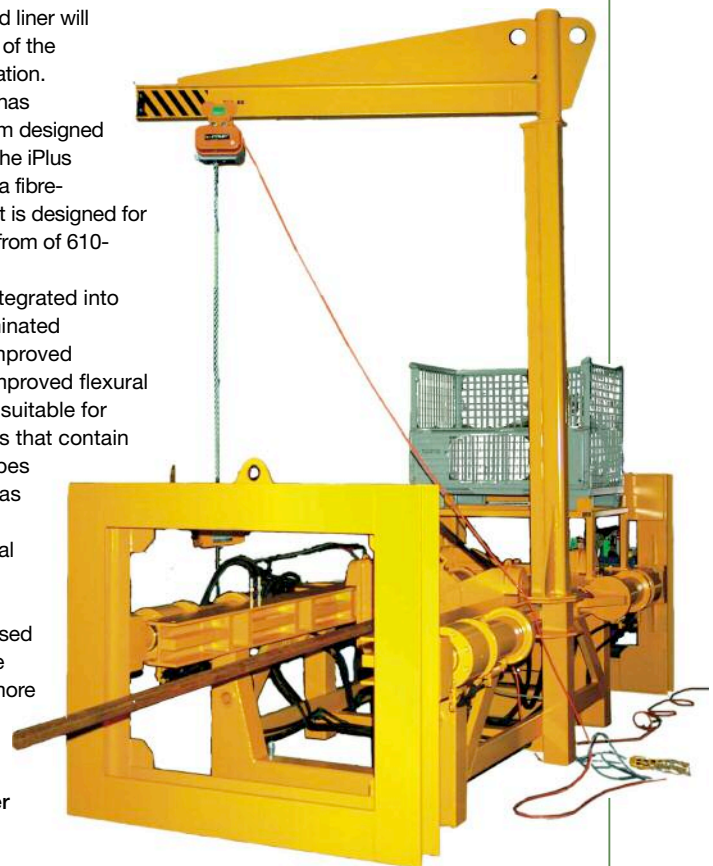
For example, where it is necessary to introduce a very thick walled liner to maintain or enhance the structural capacity of a pipeline, existing materials do not always have the capacity to meet these requirements or the installed liner will reduce the overall capacity of the pipeline for long-term operation.

Insituform Technologies has recently developed a system designed to eliminate this problem. The iPlus composite liner comprises a fibre-reinforced liner material that is designed for rehabilitating gravity pipes from of 610-2,100mm diameter.

Reinforcing fibres are integrated into the liner wall to form a laminated sandwich structure with improved physical properties. The improved flexural strength makes iPlus liner suitable for non-circular cross-sections that contain straight sides (eg egg shapes or flat-bottom arch pipes) as well as those likely to be subject to higher than usual external loadings (eg high long-term traffic flows).

The iPlus enables increased flow capacity relative to the host pipe compared with more

**Right:** Perforator's RBZ160 pipe-burst rig, is the defunct older brother to the RBZ60





**Above:** Section through Insituform's new iPlus composite liner for pipe renovation

Independent testing of iPlus carried out at Coventry University, UK, established the E-Modulus of the cured liner to be over 5000Pa. One of the three samples tested showed an E-Modulus of over three times the industry recommended level of 2200Pa for this type of liner.

There has also been progress over recent years in lateral connection seals. For example Trelleborg announced that both its 45° and 90° lateral seal product passed WRc's long-term infiltration test, in accordance with the infiltration limits set under the Sewers for Adoption 6th Edition (based on the BS EN 1610 standard) for this type of installation. The WRc test requires installation of the lateral seals to be made into four independent test rigs where clayware pipes are installed, without damage, in a manner similar to those used on real-life installations in the ground. This includes three months exposure to an external hydrostatic water pressure head of up to 5m in a cyclic pressure regime

**Right:** The Pipehawk e-Spade ground probe radar is a recent addition to the field

**Below:** Diagram showing a Flusher demountable unit in position. Developed by Infotec, the Flusher automatically cleans a sewer of detritus



designed to imitate a working cycle likely to be encountered by the product in service. The leak tightness of the lateral seals is regularly monitored over the test period.

Brawoliner has introduced Brawoliner satellite packing pieces and collars. These units are designed to meet the requirements where renovating faulty pipe unions. Brawoliner supplies a tight-fit solution for German-standard DN 100-DN 225 main pipes and DN 70-DN 225 feeders. The new satellite packing pieces and flexible collars allow fast, easy, affordable and reliable renovation of even complex fall pipes.

The renovation of building down-pipes is also becoming a growth area for the use of trenchless systems normally applied horizontally. With increasing numbers of buildings having deteriorated down pipes that have been built either inside the structure or which are otherwise difficult to access, the need to renovate these pipes without disruption to the building, its occupiers or the system is becoming more widespread. The technique has also become available for the lining of waste chutes within high-rise buildings for similar reasons.

#### Ancillary developments

Across the trenchless technology market it has long been a wish to develop a system of ongoing pipe maintenance that minimises the need for internal intervention, particularly where this would require confined space, man entry. One



requirement has been how to keep operational sewers and drains clean.

One system that has been developed to meet this need has been the Flusher, introduced by UK-based Infotec, which is more widely known for its expertise in the field of utility and buried systems tracing and mapping.

Flusher is an innovative drain and sewer cleaning system that utilises the potential energy within the sewer to clean itself and the surrounding catchment area. The system can be demounted and moved to different locations, enabling it to be used as an effective maintenance tool and an environmentally-friendly solution.

It is a gate device that, once installed, starts initially in a closed position, causing effluent flows to accumulate on the upstream side of the gate. When the flow reaches a set level, the gate opens fully, releasing the contained effluent to surge through the sewer in high volume and at a high flow rate, so scouring fats, silt, or other built up material from the sewer walls and out of the invert. The process is continually repeated allowing any materials or deposits left behind by one cleaning action to be removed by the next. Because the flow level varies, deposit build ups are dramatically reduced throughout the pipeline. A range of pre-fabricated Flusher systems is available for pipes of 100-600mm nominal diameter.

Remote sensing units and techniques are increasingly being utilised to minimise disruption during surveys or buried services. One of the most recent additions to the field is the PipeHawk e-Spade ground probing radar system. Using ultrawide band co-polar antennas within an impact-resistant moulded body, the e-Spade radar signal feeds information to the on-board, high-spec processing computer. This is controlled via icon-driven software for ease of use with built-in USB ports for quick and easy data transfer. The most up to date communications technology can also be used in conjunction with such systems, interfacing site with office and client as required.

The PipeHawk e-Spade is available in three models including; the Standard e-Spade designed for low use requirements, e-Spade+ that has the addition of the latest version of PipeHawk's tried and tested mapping software, and the e-Spadepro at the top end of the range for high accuracy, professional utility surveys with a global positioning system (GPS) facility.

So it can be seen that trenchless technologies not only continue to develop but are also finding new areas of application. T&T



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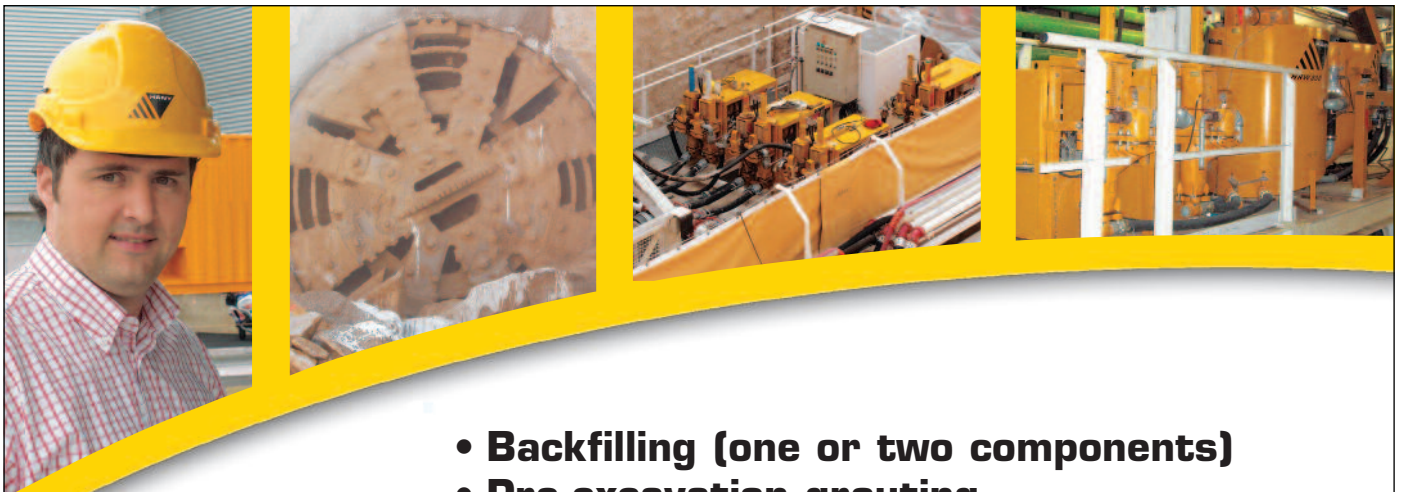


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# Examining pipe bursting safety

At least one accident to operators during pipe-bursting operations has caused concern amongst contractors, the safety authorities and suppliers. Pipe bursting consultant Jesper Nielsen looks at the issue

**T**here has probably never been more focus on the working environment than now. Construction sites are regularly closed down temporarily due to lack of signing, fencing, use of dangerous machinery and general lack of tidiness on the streets. Many more incidents are reported due to the focus on personal safety, but also the industry attitude and policy, that it is in fact correct to report an accident, however minor it might seem at the time.

In general one could conclude that the spin offs are safer sites and much fewer incidents annually involving on-site construction personnel. There is however still much to be hoped for when it comes to equipment safety and responsibility taken for that by various producers in the pipe rehabilitation industry.

Hydrostatic pipe bursting is a well-known and approved pipe rehabilitation method. Regardless of the machine brand and the differences in design, the method of how the old pipe is replaced is based on the same principals.

## General method

One or more hydraulic rams are mounted in a horizontal frame, providing the pull or push thrust needed for pipe-bursting. A gripping mechanism, attached to the horizontal cylinders, holds on to a steel rod that is either screwed or linked together with it. The gripping system may be a mechanical linkage or hydraulic according to the brand.

Mechanical systems operate by a one-way, non-positive grip, which does not control the



Above: The three pipe-bursting rigs on test laid out in parallel

rods in case of a mechanical rod failure.

The hydrostatic system operates by having a constant positive grip around or behind the steel rod during the pullback. This system provides complete rod control in case of a mechanical rod failure.

Using a known force the machine pulls, via the steel rods, a 'bursting tool' through the ground, breaking the existing pipe and inserting a new product pipe. The amount of pulling force varies with machines pulling at up to 400 tonnes force is available

## Reported incident

On the 27 June 2008 a machine operator of contractor G White & Son Ltd, UK, subcontracting to Enterprise, had his leg broken. The incident was reported and filed as Health and Safety Executive incident report ref 02213856. The injured person was, at the time of the accident, standing behind and operating a pipe-burster.

Due to a mechanical failure in which one of the connecting rods broke, the remaining rods shot backwards out through the back of the machine, hitting and breaking the operator's leg on impact.

Nearly a year went by without any

serious steps taken to analyse the accident. What actually happened on the 27 June 2008, could it happen again and what can be done to prevent this?

## Testing

On 21 May 2009 some of the biggest trenchless construction companies in England sponsored and organised a pipe-bursting safety test to specifically focus on the topic of safe pipe-bursting machines.

Equipment from the three main suppliers and producers of pipe-bursting machines were rented or borrowed for the event. These were:

- the 400G Grundoburst distributed by TTUK in England and rented from A-Plant;
- the Hammerhead Hydroburst HB5058 produced by the Earth Tool Company in US, and rented from UMole in the UK;
- a T45 hydrostatic Pipeburster on loan from the producer, Scandinavian No-Dig Centre, Denmark, and distributed in the UK by TA Drilling Enterprise

The three rigs were set up in parallel lines, connected to the hydraulic power pack of each, and with 18m of 4-in. (100mm)-diameter ductile iron pipe lined up in front



**Above left:** Tracto-Technik QuickLock bursting rods and anchor plate; **Left middle:** Adapted bursting rod with bolt connector and anchor plate; **Left bottom:** Anchor plate connector and a sheared bolt; **Above right:** Demonstration attendees discuss the issues

disc larger than the outside diameter of the pipe, so this disc acts as an obstruction or anchor plate.

Each unit pressed 20m of rods through the ductile iron pipe, to the end, and the first rod fixed at the opposite end, 20m from the machine. The test method is that when pressure is applied by the normal rig operation a load is exerted onto the shear bolt as the rods are pulled back. The pressure is built up until the bolt snaps. When the bolt snaps the energy is transferred to the rods resulting in a reaction. This reaction was to be viewed during the demonstration.

**Pre-demo trials**

Four tests were conducted with each of the three rigs prior to the demonstration. This was to observe the reaction effect and the set up so that the demonstration was safe for the invited personnel. Scandinavian No-Dig had previously performed several tests in Denmark and had set out a method statement with a safe procedure for this demonstration.

**Demonstration**

The demonstration, as the trails, was held in front of client, contractor and manufacturer representatives in Whetstone, Leicester, England. The results of the demonstration mirrored the trials virtually the same for each machine.

A test was done with each rig using a 25-tonnef bolt. The bolt strength was reduced to 10 tonnef. The results were

the same but the strain on each machine was reduced. It was then decided to conduct the demonstration with a 10-tonnef bolt for safety reasons.

During the testing it was noted that, when the bolt snapped, the pipe moved away from each rig approximately 300mm. To overcome this action and simulate a buried pipe an excavator was used to butt up the pipe to the bursting machine to prevent any lateral pipe movement.

**HB5058**

Four tests were completed of the Hammerhead Hydroburst from U Mole plus the demonstration. Each resulted in the rod ejecting from the rear of the rig to a distance varying from 600mm to 1000mm. The maximum was achieved during the demonstration.

**400G**

Four tests were completed of the Tracto-Technik Grundoburst from TTUK, plus the demonstration. The results showed that the minimum distance the rod was ejected was 1500mm and the maximum was 2500mm. In the demonstration the ejection was 2000mm.

**Scandinavian T45**

Four tests were completed plus the demonstration. All the results were virtually identical. The rod was held within the machine with zero ejection but the whole rig moved from a minimum of 40mm to a maximum of 60mm. The lateral movement of the rig during the demonstration was 50mm.

T&T

**REFERENCES**

The detailed papers on the test can be viewed at [www.safepipebursting.com](http://www.safepipebursting.com)

to 'burst'. Each then had its bursting rods inserted, with a rod from each machine adapted (drilled and tapped to take a 20-mm M20 bolt). The bolt, having known shear strength, was fitted through a steel



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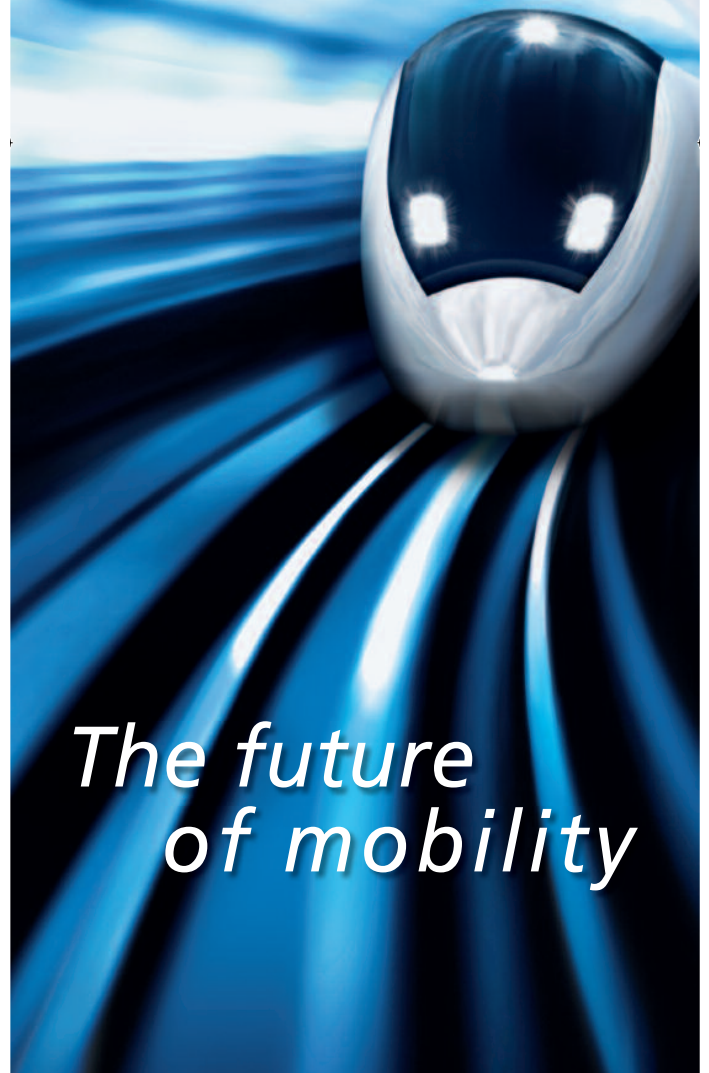


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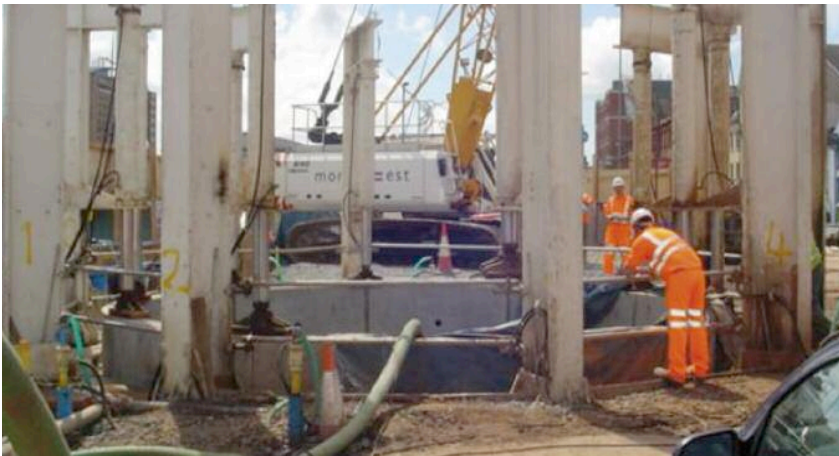
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# Belfast Sewers Project – part 2

The Belfast Sewers Project was presented at the November 2009 meeting of the British Tunnelling Society. In the second of two articles on the project, Paul Ronicle of the Morgan Est - Farrans JV describes the construction challenges



**Above:** Jacked caissons and dewatering allowed the JV to sink dry

**T**he geology of Belfast consists mainly of Sherwood sandstone, a weak cemented sandstone, which extends across Northern Ireland and the north of England. The sandstone has been eroded by glaciations and is overlaid by glacial deposits of sands, gravels, clays and in the upper layer the notorious Belfast sleet, a marine silt, which is highly plastic and extremely weak. One peculiar feature of the Sherwood sandstone in Belfast is that it has been intruded vertically with quartz dolerite in the form of dykes, and where you encounter the bedrock, you would specifically encounter a dyke at 120m centres. Although the tunnel horizon had been optimised in the alluvium on this project for simplicity of construction, there was about one kilometre of tunnelling through the sandstone encountering fourteen dykes during the construction phase. The water table was near to the surface with 2bar water pressure at the tunnel horizon.

A great deal of work was undertaken with the site investigation with 59 new

boreholes, a dozen cone penetration tests (CPT) and geophysical surveys to locate the dykes.

The tender required a geotechnical interpretive report with ground reference conditions and Benaim Associates were engaged to produce this for the JV as they were well known as experts in the Belfast geology. The Morgan Est - Farrans JV therefore believed they had a very robust approach to ground risk, with extensive sight investigation, an Engineering and Construction Contract 2 option Pain/Gain Contract and ground reference conditions as a benchmark. However, the author says he was taken by surprise with the tremendous variety and unreliability of the geology. The sight investigation, extensive as it was, failed to identify the significant amount of boulders in the upper Boulder Clay.

The geology determined the working method with the shafts sunk as jacked caissons in conjunction with dewatering, so

the JV could sink dry whenever possible. They were completed in any depth of rock with underpinning.

## Shafts

There were two serious heritage structures in the middle of Belfast adjacent to shaft 10; the Seaman's Mission and the Port Authority Building. At this point of the contract, the JV was experiencing some difficulty with deformation on the cutting edges of the caisson ring, and so the method was changed from caisson to underpinning prematurely. There was no understanding what was wrong with the cutting edges, as they had been designed and used for long periods of time, but in the end they were changed from bolted connections to fully prepared welded connections. This cured the problem.

As shaft 10 had to be sunk, the JV was concerned with creating a problem with the heritage structures, so one wrapped caisson was constructed consisting of a segmental caisson surrounded by 300mm of in situ reinforced concrete producing a much stiffer structure. The caisson was sunk down 34m with a circularity of plus or minus 20mm. The JV debated the wrapped caisson after the project completion and agreed that in hindsight, a thicker section of shaft required a much more substantial cutting edge, and they thought the cutting edge was much more defining in the circularity than the wrap. However, the wrap did offer advantages at that location.

The tunnels were bored using a soft ground adapted EPBM supplied by Lovat; a machine that produced a predictable surface impact, which was essential in the built up urban environment of Belfast. This machine had mixed face capability and worked well in the variety of ground and mixed soil conditions.

In addition, the tooling on this machine was flexible, with scraper teeth used for the clay conditions and ripper teeth for the sandstone.

The TBM also had the facility for back loading cutters, enabling the JV to change over to roller discs for the dolerite. The

quantity of dolerite dykes was unknown at the time, with the sight investigation only picking up one, which was highly fractured. The individual pieces of dolerite when tested, achieved between 90 and 150 MPa, proving to be a robust material.

However, the JV was convinced that ripper teeth or disc cutters would work sufficiently, but as a last event, blasting was retained as an option. Drilling and blasting would be through the flood doors in discrete elements, then rotating the cutter head and drilling and blasting again.

The machine was originally being launched from shaft 10 but the JV had serious problems sinking this shaft to its full depth, so to preserve the program the TBM was launched from shaft 11. Shaft 11 was a 10m shaft, which meant ending up with a sectional launch with a short front shunt, driving forward with umbilicals and gantries placed on surface.

Shaft 11 was in the heart of the docks with no neighbours, so the equipment that was brought in for the whole project was used. These included two cranes, hoisting skips, with the rings placed on their backs directly onto the segment bogies. This was a relatively simple system, which achieved approximately 23m a shift in the alluvium and half this figure through the sandstone section.

### The tunnels

The 4m tunnel was bored between the pile caps of the Cross Harbour Bridge. The most difficult part was in the city centre, where there was potential for dolerite dykes and sandstone in a tunnel invert, with a mixed face and running sand above axis. Scraper teeth were initially used in the clay section as the JV was not expecting to encounter any boulders.

However, shortly after launch boulders were encountered, which actually broke the screw resulting in grizzlies being fitted. This configuration was used for boring through the sandstone and eventually through the dykes. There was a couple of short drives on the 2.4m drive with the most interesting drive, according to Ronicle, through section seven to one, a 2.6km section, crossing the Dublin Belfast Railway Line and then under the urban West Link Express Way, which was crossed a second time further up.

The works were 24/7 in this location with the shaft top and the essential working area in this section covered with an acoustic shed, which gave 14 dBA attenuation. The shed was 34m long, 19m wide and 8m under the crane beam.

**Right:** The 2.4m clay cutter head above and pipe jacking below

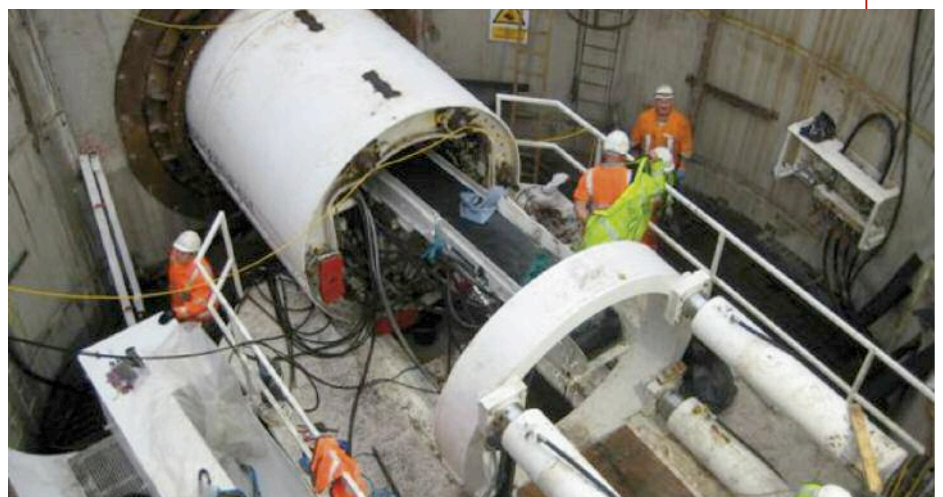
The work was much more mechanised in the 2.4m diameter section using a high altitude conveyor for the muck removal. In the pit bottom, the rings went down into a tippler, which placed them onto the segment cars. The mucking equipment was side tipplers, dumping into a hopper underneath the pit bottom, then to a chain conveyor to the high altitude conveyor, eventually up the High Angle Conveyor (HAC) into the stacker. The HAC proved a great success on this project coping with sandy soup, gravel, clay, sandstone and blocks of dolerite.

The 2.4m machine went through an interesting development throughout the course of the project. The machine originally arrived at site with a soft ground head from the previous project and the JV achieved an average of 2.6m a shift on the first drive of a couple of hundred metres. Due to the painfully slow progress, it was

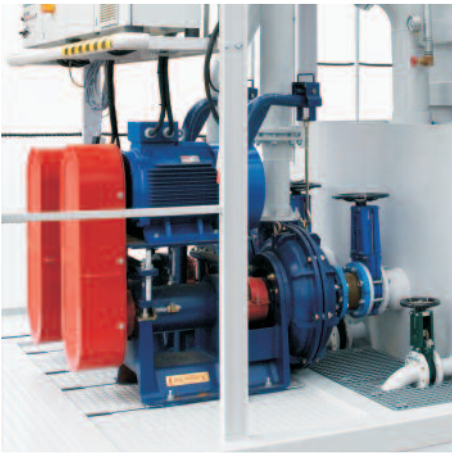
decided to make serious modifications to the machine. Having completed that first drive it eventually went into contaminated sandstone achieving 8m a shift during this time, which gave the JV a period of grace to work with the original head.

The modifications made to the machine were mainly in the soil conditioning and the way the material came out of the cutter head. The soil conditioning agent holding tank was inadequate, with a single pump feeding multiple ports at the front of the machine. This gave little control to where the conditioning agent went, along with zero feedback to the operator. Three foam pumps were eventually fitted, each dedicated to each port along with a much larger holding tank.

A dedicated polymer pump was also fitted to feed polymer into the screw conveyor, with feedback on flow rates and



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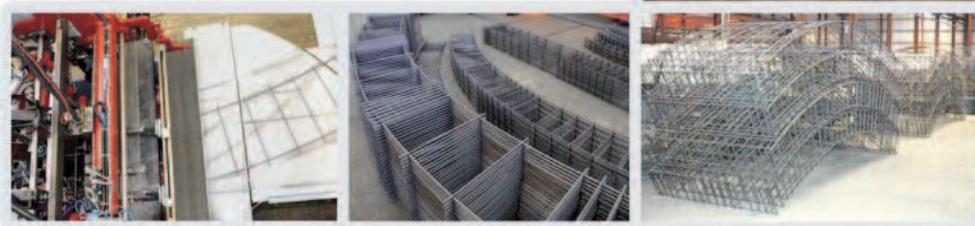
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percentages to the operator. Due to the sticky nature of the Bolder Clay, a stationary muck knife was also installed, which peeled off the clay as the drum rotated dropping the clay into the muck ring for removal.

The new improved head was launched from shaft 7, limiting the opening so the operator could peel the clay off in a controlled manner.

The machine achieved approximately 100mm a minute penetration, which would have produced the required 20m plus in a shift. However, the JV's euphoria was short lived, as before it had even buried the shield, the drive ran into substantial quantities of boulders, which choked the Archimedian screw.

The JV was forced to put compressed air on the face, pull the screw out, clean it out and then modify the machine to a universal head. The team limited the openings at the excavation head right down to approximately 90mm to lessen the amount of stone, which could have entered the screw and broken it.

The head was also fitted with very large saddle teeth with tungsten carbide inserts, which broke everything it came across. However, this came at a price as only 17m a shift was achieved through the alluvium and 10m through the sandstone. The saddle teeth were worn but intact at the end of the drive but the gauge teeth were completely obliterated.

### Contaminated ground

The middle of the job tunnelled under the old gas works site, and at the time of tender there was one borehole that showed very limited amount of hydrocarbon contamination. Additional boreholes were sunk once on site finding toluene, xylene and benzene contamination in the ground water. Because Benzene is a carcinogen, the water from the dewatering wells had to

be treated after discharge. The water went through an oil and grit intersection and then through large activated-carbon filters. The shafts were then sunk in the dry and although there was no measurable concentration of benzene, there was a significant odour from the coal tar.

As a precaution, the crew were equipped with exposure suits, which offered ten times occupational exposure limit (OEL) protection from benzene.

The contamination was above tunnel horizon and the JV perceived that once it turned off the dewatering prior to tunnelling, the water table would recover and light fraction hydrocarbons would float on the top cancelling out any issues.

As a precaution, the JV took advice from the UK Health and Safety Executive (HSE) and Employment Medical Advisory Service (EMAS) and prepared for contamination just in case they hit it. In the end they hit substantial concentrations of contamination during the drive and subsequently fitted out the crew with exposure suits able to withstand 40 times OEL protection. Every time the crew came out of the shaft they went through a decontamination procedure, which involved showering down to clean the suit off and discarding the chemical over-suit and their gloves into a chemical waste skip.

Industrial work wear was also laundered on site to avoid contamination.

### Under pressure

Compressed air was used several times on the project, once for damage to the articulation in the 4m-diameter machine and once to a damaged screw in the 2.4m-diameter machine. It was also used in shaft breakouts, which was not anticipated at the time of tender due to the unreliability of the ground.

The JV only ever expected to do interventions, so they had a fairly simple

**Above:** Contamination suits extended the allowed working hours

**Above left:** Boulders broke the TBM's Archimedian screw

setup with a boiler lock and oxygen bibs for decompression. The JV operated to Northern Ireland regulations. The current standard is the Blackpool Tables for oxygen and re-breathing, the JV was not keen on using these partly because if you typically work four to six hours at two bar, in the last stage of decompression you have to breath oxygen through a bib for forty minutes at only 0.2 bar over atmospheric pressure. This would have proved very uncomfortable.

The JV's advice was to use the German dedicated oxygen tables now called the Swanscombe Tables, following their successful use on the Channel Tunnel Rail Link Project. The JV approached the HSE and gained approval to use the Swanscombe Tables although the HSE asked the JV to undertake original medical research to monitor the evolution of bubbles in the blood stream during the decompression process. This was undertaken through 75 high pressure exposures through Doppler monitoring.

The only other change in Belfast was the switch to using MRI scanning instead of the traditional long bone x-rays used as a diagnostic method for bone necrosis in people who have been exposed to high pressures. EMAS in Northern Ireland were keen to minimise the exposure to x-ray radiation wherever possible. EMAS approached a consultant radiologist and eventually the Institute of Radiologist and convinced the JV that MRI scanning was a valid tool for bone necrosis. There was a big cost difference, with long bone x-rays at £150 (US\$243) a set and £2000 (US\$3237) for a scan.

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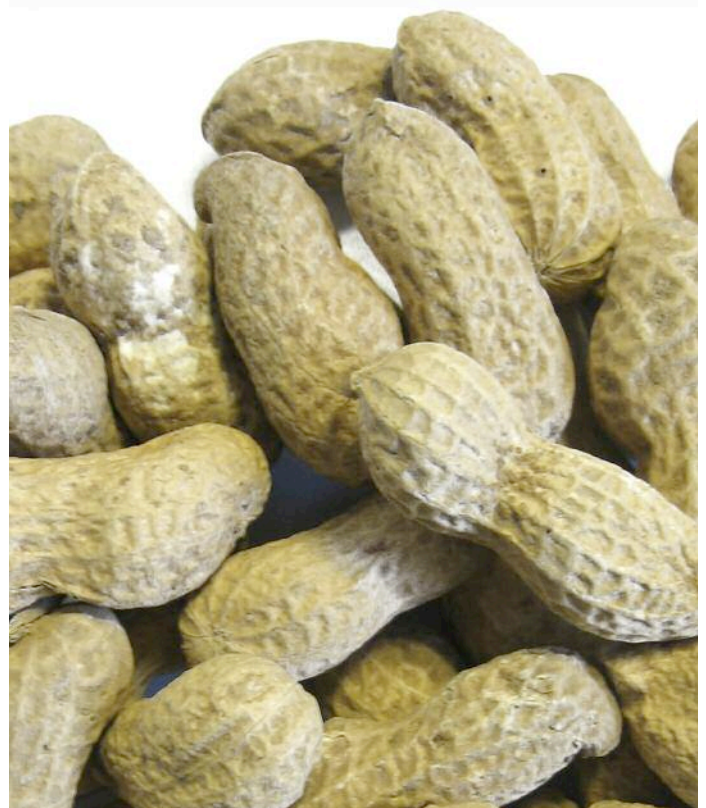
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# Dates & Events

**4-5 MARCH 2010**

## **World Tunnel Congress China, Shanghai, China**

The WTCC will focus on China's challenge to build 300km of tunnel every year. Contact: email: yi.wang@hnmzmedia.com; tel: +86 21 5101 3735 or +86 21 5101 3738; fax:+86 21 5101 6269; web: www.hnmzmedia.com/events/WTCC

**17-19 MARCH 2010**

## **ISTSS 2010 Frankfurt, Germany**

The 4th International Symposium on Tunnel Safety and Security. Manuscript abstracts should be submitted to the Secretariat by 01 June 2009, poster abstracts by the 01 October 2009. Contact: Anders Lönnermark, SP Technical Research Institute of Sweden; tel: +46 10 516 56 91; email: anders.lonnermark@sp.se; web: www.sp.se

**17-19 MARCH 2010**

## **INTERtunnel RUSSIA 2010 Expocentr, Moscow, Russia**

INTERtunnel Russia 2010 provides an opportunity for suppliers of products and services to the tunnelling sector to showcase their capabilities and exchange ideas and experiences. INTERtunnel RUSSIA will be held at the Expocentr in Moscow, Russia Contact: email: intertunnelrussia@mackbrooks.com; web: www.intertunnelrussia.com

**18-19 MARCH 2010**

## **4th China Tunnel Summit, Shanghai, China**

Among the key issues of this summit will be: World & China tunnelling development trends; Hard rock TBM issues & solutions in city subway tunneling; subsea tunnelling and speeding construction. Contact: email: marketing@merisis-asia.com; tel: +86 21 62478898; fax: +86 21 62478838; web: www.merisis-asia.com/tunnel2010

**19-25 APRIL 2010**

## **Bauma 2010, Munich, Germany**

The 29th International Trade Fair for Construction Machinery, Building Material Machines, Mining Machines, Construction Vehicles and Construction Equipment will be held in the Messe Muenchen Messegelaende 81823, Munich, Germany. Contact: email: info@bauma.de; tel: +49 89 949 11348; fax: +49 89 949 11349; Web: www.bauma.de

**2-7 MAY 2010**

## **North American Society for Trenchless Technology No-Dig 2010, Chicago, USA**

The 2010 NASTT No-Dig show will be held at the Renaissance Schaumburg Hotel and Convention Center, Chicago. The conference theme is "Rebuilding North America's Underground Infrastructure Using Trenchless Technology" and will include infrastructure investment; social costs and impacts; industry trends, advancements and new concepts. Contact: NASTT; web: www.nodigshow.com

**14-20 MAY 2010**

## **2010 ITA World Tunnel Congress, Vancouver, Canada**

Not long after the 2010 Winter

Olympics, the International Tunnelling Association (ITA) visits the spectacular city of Vancouver, British Columbia, for its yearly conference and exhibition. The usual combination of working groups, open sessions and technical talks will all be included. Contact: web: www.wtc2010.org

**19-21 MAY 2010**

## **Tunnel China, Shanghai**

With a focus on China 'The most dynamic market for the tunnelling and underground space industry in the world' the event will look at railway and highway developments and feature trenchless technology. Contact: web: www.tunnel-china.org

**8-10 JUNE 2010**

## **InterTunnel 2010, Turin, Italy**

Tunnelling exhibition aimed specifically at clients, contractors and consultants involved in the construction of and equipping and operation of tunnels. Contact: Mack Brooks Exhibitions; web: www.intertunnel.com

**9-11 JUNE 2010**

## **Swiss Tunnel Congress, Lucerne, Switzerland**

Tunnelling developments in the Alps will doubtless be a talking point at the Swiss Tunnelling Society's STC. The event will be held at the KKL Lucerne. Contact: fgu@thomibraem.ch web: www.swisstunnel.ch

**14-16 JUNE 2010**

## **International Conference Underground Construction Prague 2010 Transport and City Tunnels**

The Czech ITA-AITES Tunnelling Association will host its 11th International Conference at the Clarion Congress Hotel Prague. Lectures will be simultaneously interpreted into English, German and Czech. Contact: Czech ITA-AITES; tel: +420 266 793 479; email: ita-aites@metrostav.cz; web: www.ita-aites.cz

**15-17 JUNE 2010**

## **European Rock Mechanics Symposium (EUROCK 2010)**

Eurock 2010 is an ISRM Regional Symposium of Europe. The Symposium covers all the aspects of rock mechanics and rock engineering. Contact: Jean-Paul Dudt, Laboratory for Mechanics of Rock (LMR). EPFL-ENAC-LMR Station 18 CH-1015, Lausanne; tel: +41 21

693 23 25; fax: +41 21 693 41 53; email: lmr@epfl.ch; web: www.lmr.epfl.ch

**19-23 JUNE 2010**

## **North American Tunneling Conference, Portland USA**

The 2010 NAT will be held at the Marriott Downtown Waterfront Hotel in Portland, Oregon. Conference and exhibition information and registration is available on the SME web site. Contact: Society for Mining, Metallurgy and Exploration (SME); web: www.smenet.org.

## BRITISH TUNNELLING SOCIETY

### **10 FEBRUARY: Joint Meeting with MinSouth. Construction of Road Tunnels in Iceland Hédinsfjardargöng Project**

The speakers will present the history and highlight the main problems, which were met during the planning and construction of the Hédinsfjardargöng Project, which includes two road tunnels, 3.6 km and 6.9 km long. The project is located in the north of Iceland and during the construction of this drill & blast. ICE 5.30pm for 6pm start.

### **17 MARCH: Gotthard Base Tunnel Project - Switzerland, Transco Sedrun**

Michael Gutzeit & Hans-Juergen Bartschat of Bifinger Berger Ingenieurbau will give a presentation on the challenges faces on the Gotthard Base Tunnel project. Please note this is a Wednesday meeting. ICE, 6pm for 6.30pm start.

### **15 APRIL: Harding Lecture - Risk vs Innovation**

Alistair Biggart presents this year's Harding Lecture. ICE, 5.30pm for 6pm start.

**12 - 16 SEPTEMBER 2011**

## **6th International Symposium on Sprayed Concrete, Norway**

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

**23 - 27 OCTOBER, 2010**

## **ISRM international Symposium 2010 and 6th Asian Rock Mechanics Symposium, New Delhi, India**

Contact: Mr. V. K. Kanjlia, Member Secretary, Indian National Group of ISRM: tel: +91-11-2611 5984/2688 2866/2410 1591; fax: +91-11-2611 6347; email: uday@cbip.org/ cbip@cbip.org; web: www.arms2010.org

## A DATE TO REMEMBER...

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

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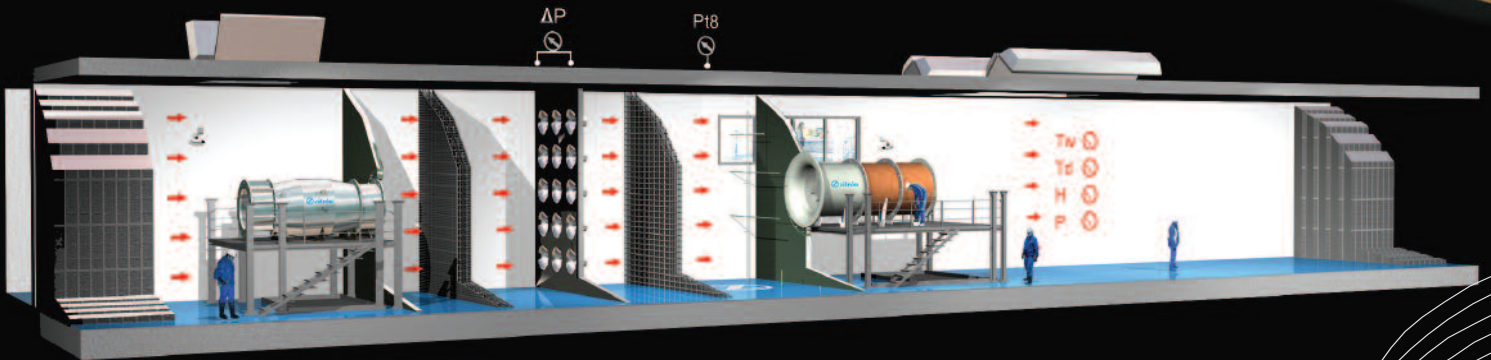
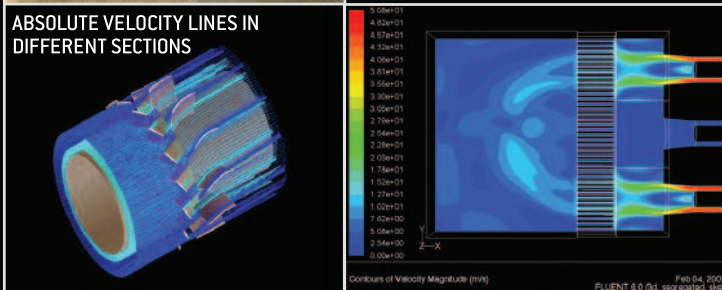
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