

INTERNATIONAL EDITION

February 2014

# Tunnels

AND TUNNELLING



## SHOCK AND AWE

*Drill and blast rigs as an  
excavation option*

India • Drill and blast



# Rapid

A key role in **Crossrail**, London's new high capacity east-west link and **Europe's largest construction project**. Impressive progress of up to 33 rings (52.8m) a day. On completion there will be 42km of bored tunnels.

# Trusted

Crossrail contractors rely on Herrenknecht technology: **6 EPB Shields + 2 Mixshields.**

# Top Choice

London joins Singapore, Delhi, Guangzhou, Moscow, Kuala Lumpur, New York and São Paulo in **choosing Herrenknecht tunnelling technology** for new railways and metros.



## Pioneering Underground Technologies

[www.herrenknecht.com](http://www.herrenknecht.com)



## IN WITH THE NEW

**I**N A Finnish conference hall in 2011, Sao Paulo hammered both Singapore and Sydney, and was selected to host the World Tunnel Congress in 2014.

Every WTC seems to have its own quirks, and WTC 2014's might be that it will not be in the original city put forward in the bid, but rather at a resort located near the Iguassu Falls, a natural wonder of the world.

One story is that the organisers returned, surprised by success, to cement arrangements for the show with local facility managers, only to find that the FIFA World Cup had inflated hotel and venue prices.

Whatever the reason, the end result an additional airport changeover, two-hour flight, and a five-night minimum stay as standard across the local hotels.

The upshot is that we should not be surprised to see a greater number of junior engineers in attendance, as seniors pass over this now awkward event, in an already crowded calendar. Even the ITA sessions are expected by some to be sparsely peopled.

But maybe this is not entirely a bad thing.

editor@tunnelsonline.info

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



Alex Conacher  
Deputy Editor



For the past year, young tunnel engineers have been in communication as only the millennial generation can. They have been forming Young Members' societies in as many ITA Member Nations as possible in preparation for the possible birth of an ITA Young Members' group. With this slated as early as the upcoming event in Iguassu Falls, a throng of young engineers could give this show a new excitement.

It could be the young engineers' WTC in Brazil this May, aptly hosted by a country experiencing a new dawn in underground construction after years of stagnation.

It's worth a flight

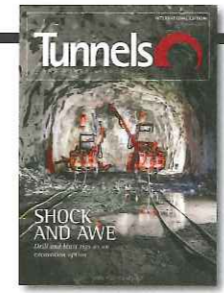
### This month...

#### 10 YEARS AGO

Malaysian contractor MMC-Gamuda was due to start boring the SMART project as *Tunnels* went to press. This will be the first of two drives on the combined road and sewerage tunnel in Kuala Lumpur, Malaysia. Machines used will be 13.21m-diameter Mixshields from Herrenknecht. The second bore contractor is Wayss Et Freytag, which will commence construction later this year. The first bore will be 9.4km while the second will be 5.3km. When open in early 2007, it will relieve traffic congestion in the city, and during the monsoon season, will be closed to traffic to allow stormwater to be diverted to the Klang River to prevent flooding.  
*Tunnels and Tunnelling, February 2004, p.7*

Two months ago the largest diameter TBM in the world broke through marking completion of boring of the 7.2km-long Groene Hart tunnel in Holland. The 14.87m-diameter slurry TBM was designed and built by NFM Technologies, part of the Wirth Group. Contractor was the Bouygues Construction/Koop JV. A spokesman said that a single, large bore was the preferred solution as it was felt to offer significant financial, safety and environmental benefits. It halved the amount of approach works required, as well as the need to excavate cross passages due to the equipping of the dividing wall with escape doors at intervals. The risk of settlement was also reduced through Holland's protected "Green Heart".  
*Tunnels and Tunnelling, February 2004, p.10*

**Cover**  
Drill and blast rigs, popular all over the world, face differing market requirements and funding



**Next issue**  
In the next issue of *Tunnels*, the regional focus switches to Western Europe, with two projects reports from France. Also featured is a show preview for the International Symposium for Tunnel Safety and Security, and a look at tunnel face investigation ahead of advance

[www.tunnelsonline.info](http://www.tunnelsonline.info)

# ALWAYS ADVANCING

www.terratec.co



## DELHI METRO: 8 EPBMs FOR PHASE III

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

By selecting TERRATEC, the contractors not only get the best equipment designed to the highest standards and delivered in time, but also a comprehensive package of services to assist the TBMs' assembly, operation and maintenance.

### News

- 7 *World news*  
The latest project updates, announcements, and tunnelling advances from jobsites all around the world
- 18 *Business news*  
Corporate and personnel changes, key decisions and financial news from global tunnelling companies
- 20 *Big picture*  
This month's big picture shows the breakthrough of the world's first variable density TBM. The Herrenknecht machine found daylight at Pasar Rakyat Station on the Klang Valley MRT project in Kuala Lumpur, Malaysia

### Indian Subcontinent

- 23 *Market performance overview*  
**Danny Richards, Timetric**  
Timetric, the data and market analysis arm of Tunnels' publisher World Market Intelligence presents this report on projected growth and performance of the infrastructure construction market in India, working forwards to 2017, based on observations and study over a period up to 2012
- 28 *Uttarakhand disaster*  
**Mahendra Bisaria, Gammon Infrastructure**  
In the wake of devastating floods in northern India last June, environmentalists have accused hydropower infrastructure of causing a man-made disaster. Mahendra defends the use of hydropower by exploring the region's geology, and the development and construction processes for such projects
- 35 *Ovulavaripalle to Venkatachalam railway design*  
**Sergio Sanchez-Rodriguez, Ayesa**  
**Mariano Alvarez-Arce, Ayesa**  
**Ruben Moreno-Bernal, Ayesa**  
**Alberto Jaen-Toribo, Ayesa (formerly)**  
The engineers of Ayesa discuss the detailed design of this rail tunnel project in the state of Andhra Pradesh, on the southeast coast of India. Two greatly differing levels of overburden between tubes call for bespoke support
- 40 *Delhi Metro site experiences*  
**Alex Conacher, deputy editor**  
Supplying eight of the 25 TBMs required for Delhi Metro's Phase III, manufacturer Terratec is heavily invested in the project. In a series of vignettes, Tunnels checks out how the different worksites are being handled in a city crowded far beyond its infrastructure capacity

### Drill rigs

- 47 *Drill rigs as an excavation choice*  
**Rhian Owen, freelance journalist**  
Less developed markets may require lower standards in machinery specifications, but the temptation to produce substandard equipment must be avoided, according to manufacturers of drill and blast machinery



### Contributors

#### *Mahendra Bisaria*

Mahendra Bisaria is a management consultant at Gammon Infrastructure in Mumbai. He is in overall charge for the development of hydropower projects through Special Purpose Vehicles. He has one 60MW Project in Sikkim is under construction and two other projects, 261MW and 60MW respectively, in development stages. He has 55 years of experience in civil engineering covering project formulation, tendering, their evaluation, award of contracts, execution of works and arbitration. He writes in this issue of Tunnels on the impact, or lack thereof, inflicted by construction practices in light of recent Himalayan flooding. Read him on p.28

#### *Sergio Sánchez-Rodríguez*

Sergio is a civil engineer and the department head for geotechnical engineering at Ayesa. In this issue, he and his colleagues (below) write on the detailed design of the of NATM tunnels on the new Ovulavaripalle to Venkatachalam railway line in Andhra Pradesh, India. Read him, Mariano, Rubén, and Alberto on p.35

#### *Mariano Álvarez-Arce*

Mariano is Ayesa's manager and the director of civil engineering and architecture in India: Ayesa Engineering - India.

#### *Rubén Moreno-Bernal*

Rubén is a senior geotechnical geologist, based in Ayesa's Madrid office as part of the civil engineering and architecture practice.

#### *Alberto Jaén-Toribio*

Formerly a geotechnical and tunnel design engineer with Ayesa Engineering's department of ground engineering and tunnelling, Alberto currently works for Halcrow, based in London.



© photo credits: VINCI, Crossrail, BBMV and MVB photo libraries

## CONSTRUCTING A SUSTAINABLE FUTURE

At VINCI Construction Grands Projets, we engineer solutions that are not only financially competitive, but also work in a way that is sustainable for the planet.

Sustainability goes beyond the care we take in protecting our people and our environment. It's also a commitment to offer new solutions to our clients and stakeholders.

### We nurture Innovation.

Every two years, the VINCI Innovation Awards get increased entries, reaching 2,075 in 2013. These awards reflect the core values of the group and we are proud at VINCI Construction Grands Projets that the Lee Tunnel project (Thames Water) was awarded the Grand Prize in the UK & Ireland.

To learn more please visit [www.vinci-construction-projects.com/british-isles](http://www.vinci-construction-projects.com/british-isles)



Discover more...



GRANDS PROJETS

# ALASKAN WAY TUNNEL STILL STALLED

**USA** The State Route (SR) 99 tunnel crews identified an obstruction that halted the TBM in early December 2013, Washington State Department of Transport (WSDOT) announced in January. The TBM for the USD 2bn tunnelling scheme in Seattle had been at a standstill after experiencing unexpected resistance some 1,000ft (304m) into its drive.

WSDOT's design-build contractor for, Seattle Tunnel Partners (STP), a joint venture of Dragados USA and Tutor Perini, drilled 17 exploratory probes in front of the TBM to look for objects that might be blocking the machine's path.

In early January contractor crews successfully reduced water pressure enough to visually inspect a portion of the excavation chamber. A piece of an 8in-diameter steel pipe could be seen protruding through an opening in the cutterhead. Probes from the surface also detected metal in front of the machine.

The steel pipe is a well casing installed in 2002 following Seattle's 2001 Nisqually earthquake to help geologists better understand how groundwater moves in

this area of the city.

WSDOT said the location of this pipe was included in reference materials in the contract it holds with STP.

"This is just the first step in determining what's obstructing the machine," said Matt Preedy, Alaskan Way Viaduct Replacement Program deputy administrator.

"We need to investigate further to see if there are other factors that could have contributed to the blockage."

STP is considering several options to remove the steel pipe and identify other potential obstructions, WSDOT stated.

"It's still too early to know how this issue will affect the project's schedule and budget," Preedy said.

"Our focus right now is on resuming tunnelling as quickly and safely as possible."

As the process to find and remove the blockage continues, tunnel workers are also conducting critical maintenance,

inspecting and replacing damaged cutter tools, WSDOT reported.

The TBM, Bertha, is excavating a 3.2km-long tunnel to replace the SR 99 Alaskan Way Viaduct in Seattle.

The 57.5ft (17.5m) diameter TBM, manufactured by Hitachi-Zosen of Japan, launched on July 30, 2013.

In December 2013 Bertha tweeted that she is working fine but has encountered an obstruction.



Pieces of the steel pipe, image courtesy of WSDOT

### New tender announced for Fehmarnbelt tunnel

**Denmark** Copenhagen-based client, Femern, which is in charge of the preparation and planning of the Fehmarnbelt tunnel, announced another major tender. The work concerns a large sub-station on Lolland, providing power for the electric trains, which will operate through the tunnel and for the electrical systems in the tunnel.

Nine international consortia are already in the process of submitting tenders for the tunnel itself.

Femern recently announced the tender for the installation of the electrical and mechanical systems in the tunnel.

The project will be undertaken in partnership with the energy supply company, Energinet.dk, and will comprise the installation of the substation, including transformers and switchgear for the supply of the tunnel's electricity and the catenary

system. Buildings for the switchgear, the control room and staff facilities will also be constructed.

Large amounts of power will be required to keep the electricity-powered trains in operation and to ensure stable operations and a high standard of safety in the planned tunnel.

The existing electricity grid on Lolland does not have the capacity to supply the amount of energy needed for the rail operations and the electrical and mechanical systems, said Femern.

A new large substation is necessary and this will be built close to the tunnel's ramp and portal system at Rødbyhavn.

Steen Lykke, technical director, said: "The installation of major transformers with their control equipment targets major international or national specialist contractors or sub-contractors."

"But I can also foresee that some of the works

involving buildings and electrical installations will appeal to small firms."

At a later date, Femern A/S will be putting another rail-related contract out to tender, the track and catenary system the company stated.

On 21 January, Femern hosted an 'industry day' where companies interested in tendering as well as any sub-contractors received a detailed review of the content and nature of the tasks.

The tunnel is expected to be open in 2021. It will be approximately 18km-long and will have two rail tubes and dual two-track road tubes separated by a service and escape corridor.

### Gotthard Base Tunnel test trains launched

**Switzerland** Swiss transport minister Doris Leuthard launched the first official test train into the 57km-long Gotthard Base Tunnel on 16 December 2013, AlpTransit announced recently.

The test train travelled over the approximately 13km-long pilot section from Bodio to Faido at a speed of 160km per hour.

The operation also marked the 900-day countdown to the completion of the Gotthard Base Tunnel project, which is scheduled for December 2016.

All installations over the whole length of the twin-bore tunnel, including track, catenary, power supplies, signalling and telecommunications systems are due to be completed in October. The first test runs through the entire tunnel will be made in 2015.

The schedule calls for the tunnel's inauguration to take place in the first week of June 2016.

"On the weekend of 4 June 2016, there will be a big celebration for the public," Leuthard said.

"People of all ages will be able to participate in the project's completion and experience the tunnel."

**Last TBMs for Delhi Metro delivered**

India Terratec delivered the last two of eight TBMs for Delhi Metro towards the end of November, the company announced recently. The TBMs were officially

unveiled at a ceremony that included representatives from the client, a JV between Hindustan Construction Company of India and Samsung Engineering & Construction Group of Korea. The TBMs are to excavate in typical Delhi

soil, mixing silt, sand and clay in different proportions without presence of rock. For this the JV selected a 6.52m EPB machine with a classic soil configuration and equipped with a Spoke-Type CutterHead with a 57 per cent opening ratio, which has been proven to be efficient to excavate this type of soil in previous Delhi Metro Phases, Terratec stated.

Terratec said it designed the cutterhead to allow the cutting tools to be exchangeable for 17in roller disc cutters, making the TBM able to bore through the D-walls and cope with the presence of any unexpected obstacle on its way, such as old wells or foundations.

The segment lining will be made of RC segments with an outer diameter of 6,350mm, inner diameter of 5,800mm and width of 1,400mm. The total combined distance that each TBM will bore to is approximately 1,900m.

Once these two TBMs are launched at the site, there will be a total of eight Terratec TBMs excavating in Delhi through this year and part of 2015.

**Shortlist announced for LU link at Paddington**

Great Britain Three shortlisted contractors bidding for the contract to design and build the tunnel link between Crossrail platforms and Bakerloo line platforms at Paddington Station were announced late last month by Transport for London (TfL). The companies shortlisted are Costain Skanska JV, Dragados S.A and Morgan Sindall BeMo Tunnelling JV.

Currently, some 44,000 passengers interchange to and from the Bakerloo line during the morning and evening peak and this is set to increase when Crossrail starts serving Paddington in 2018. TfL announced that the link will help alleviate the additional passengers who will be interchanging between Crossrail and the

Bakerloo line.

"The building of the tunnel link is essential to support the increase in passengers when Crossrail starts serving the station at the end of 2018," said Miles Ashley, TfL's programme director for Crossrail and stations.

"The next stage of the process is to invite the three shortlisted contractors to engage in the Innovative Contractor Engagement procurement model, which we successfully used on the Bank Station Upgrade contract this summer, where the bids are assessed on the added value of their proposal, rather than on lowest cost."

The building of a link between the Crossrail and Bakerloo line Platforms is expected to be completed in autumn 2018.

**TBM excavates tunnel for Austrian hydropower plant project**

Austria A Herrenknecht TBM has excavated a new headrace tunnel for the Bärenwerk hydropower plant in Fusch, Austria. In six months the machine drilled through 2.8km of solid rock in the Austrian Alps, the company stated last month.

For the construction of the tunnel, Herrenknecht delivered a gripper TBM, which the company notes is specialised in fast tunnelling in hard rock. The tunnelling team made advances of up to 322m per week and 72m per day was excavated with a route gradient of 4.8 per cent. The TBM excavated through Phyllite slate, quartzite, limestone mica slate and green slate with carboniferous banded limestone.

Only five-and-a-half months after the start of tunnelling at the end of March 2013, the miners of Switzerland-based Marti Tunnelbau construction company celebrated the successful breakthrough late last year.

# NEW SUBSEA TUNNEL PROJECT UNVEILED

Qatar Work on a 12km-long ambitious infrastructure project comprising three iconic bridges interconnected by 8km-long subsea tunnels will begin in 2015 and is expected to be completed by 2021, before the FIFA World Cup.

The project, called Sharq Crossing, will connect Doha's new Hamad International Airport, Katara Cultural Village in the north and the downtown central business district of West Bay.

The crossing will include three interconnected bridges, named, 'West Bay', 'Cultural City' and 'Al Sharq' between 600m and 1,310m in length.

The Public Works Authority (Ashghal) has appointed US-based Fluor Corporation as the programme management consultant to supervise the construction.

"Sharq Crossing is an engineering masterpiece of design, and while providing an important new artery to Doha's existing road network, it will be instantly recognisable across the world and will be an emblem for Qatar," said Nasser bin Ali Al Mawlawi, President of Ashghal in the presence of H E Sheikh Abdulrahman bin Khalifa bin Abdulaziz Al Thani, the Minister of Municipality and Urban Planning.

Al Mawlawi declined to comment on the cost of the project, saying that "it is not clear yet as it is still in the early stages to calculate the cost".

The bridge linked to West Bay will be between the Sheraton and Four Seasons hotels and the Cultural City bridge will be between Katara and the St Regis Hotel, while Al Sharq Bridge will connect to Ras Abu Abboud Street near the new airport.

The bridges were designed by Spanish architect Santiago Calatrava and inspired by natural forms and drawings from the image of flying fish, Ashghal said in a statement.


The most intricately designed of the three bridges, West Bay, will have a two-deck arched structure incorporating a recreational park accessible via an elevated walkway and a funicular cableway. It will also include hospitality and recreation facilities.

The tunnel links will provide expressway of three lanes in each direction between the new airport and West Bay and between West Bay and Katara, there will be two lanes in each direction.

Heavy goods vehicles will not be allowed on the crossing for safety reasons. The bridges have been designed with a minimum number of supports to reduce long-term impact to the marine environment, the statement said.

"Ashghal, in collaboration with its partners, is confident that once complete, this technical and engineering marvel will be one of the most outstanding structures in the world," said Al Mawlawi.


Ashghal will work more on detailed designs and finalise contractors for the project in 2014, he said.



Monitor the convergence of pre-cast concrete segments in TBM-driven tunnels during construction for control and safety.

Digital Bus System: single interconnected cable from one tiltmeter to the next, to simplify installation and reduce cost.


Very low profile design, suitable for installation in the tight space around TBM's.



WORKS WITH  
**GeoViewer**  
REAL-TIME MONITORING

# profile monitoring

## for tunnel concrete segments



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

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

**rst**  
INSTRUMENTS

innovation in geotechnical instrumentation

RST Instruments Ltd.  
11545 Kingston St.,  
Maple Ridge, BC  
V2X 0Z5 Canada  
Tel: 604-540-1100  
Fax: 604-540-1005  
info@rstinstruments.com  
[rstinstruments.com](http://rstinstruments.com)

Certified System  
ISO 9001

INNOVATION IS OUR TRADITION



**DEILMANN-HANIEL**

A Member of The Redpath Group

[www.deilmann-haniel.com](http://www.deilmann-haniel.com)

## Our Experience - Your Success!

Global Competence in Shaft Sinking and Ground Freezing

## AECOM TO CONSULT ON HONG KONG TUNNEL DESIGN

**China** Aecom Technology Corporation announced January 15 that it has been awarded an approximately USD 13M consultancy contract for the design and an estimated USD 103M contract for the construction supervision of the Tseung Kwan O – Lam Tin (TKO-LT) Tunnel project in Hong Kong.

The TKO-LT Tunnel will include a 2.6-mile (4.2km), two-lane highway connecting Tseung Kwan O (TKO) at Po Shun Road in the east with the proposed Trunk Road T2 in Kai Tak Development in the west.

The tunnel, along with the Central Kowloon Route and Trunk Road T2, will form part of the city's Route 6 – becoming an east-west express link. The completion of Route 6 is anticipated to reduce the travel time between West Kowloon and TKO from 30 minutes to 12 minutes.

"Since 2009, we have been involved in the planning of this project, providing preliminary design and other services," said Aecom chairman and CEO John Dionisio.

"We are very proud to be able to contribute to the project's next phase."

addition to existing power stations. A new powerhouse, headrace and tailrace tunnel will be added, increasing annual generating capacity by 70MW.

Tunnelling work includes a 450m access tunnel and 7.40km-long headrace tunnel through hard rock.

The project was originally tendered as drill-and-blast. However, once LNS submitted an alternative TBM solution, the project owner identified the benefits of the TBM method, and asked for alternative TBM solutions from all the project's bidders, and eventually leading to the contract being awarded to LNS.

The TBM was assembled using Onsite First Time Assembly. For Nilsen, getting the equipment to site was a challenge: "The logistics were complex for bringing the TBM, conveyor system, spare parts and cutters from all over the world to almost 'the top of the world,'" he said.

The TBM was designed with 19-inch back-loading cutters for excavation in limestone, mica schist, mica gneiss, and granitic rock. Depending on the quality of the rock, the TBM may also excavate an additional 4.30km tailrace tunnel.

LNS is expecting the tunneling to be complete in summer of 2016, and the newly renovated power station to go online in spring of 2017.

### Rogfast Tunnel awards surveying contract

**Norway** The Norwegian Road Authority (NorRoad) awarded a USD 10.3M contract to VTT Maritime, for a portion of NorRoad's planned highway E39 improvement project. Under the contract, VTT will provide sea mapping, seismic surveying and measurement wire drilling at the site of a major subsea tunnel location.

The existing highway E39 is part of the European trunk road system and extends for 1,100km along Norway's western coast. The rugged terrain currently requires drivers to negotiate ferry crossings at eight deep fjords, which results in a total transit time of 21 hours between Trondheim and Kristiansand. NorRoad's planned improvement program is intended to eliminate all eight ferry crossings by installing bridges and subsea tunnels reducing the transit time to 13 hours.

Rogfast is the name given to the tunnel section to be bored under two fjords at depths as much as 385m below sea level. When completed, the Rogfast Tunnel will be the world's longest and deepest subsea tunnel open to road traffic, extending 25.5km.

The tunnel is budgeted at USD 2.15bn and is expected to be completed by 2023.



The Semmering Railway location in Lower Austria

### Consortium secures Semmering base tunnel

**Austria** Austrian Federal Railways awarded a contract worth EUR 6230M (USD 844M) to a consortium of Implenia and Swietelsky, for Lot 2.1, the 13km middle section of the Semmering Base Tunnel (SBT).

The two partners each have a 50 per cent stake in the consortium. Lot 2.1 will comprise 8.6km of TBM excavation and 4.3km of mining. The contract includes 26 cross passages, an emergency stop station and two 400m ventilation shafts to supply the entire construction site.

With a total length of 27.3km, the SBT links the country's Lower Austria and Steiermark regions. Austria's

new southern railway will serve as the central axis for trans-European routes from the Baltic to the Adriatic. Construction works started at the beginning of January and will last around 10 years.

### TBMs return to Norway

**Norway** Contractor Leonhard Nilsen & Sønner (LNS) launched a 7.2m diameter Robbins TBM for the Røssåga Hydroelectric Project.

"I am most proud that LNS has been able to bring TBMs back to Norway after 22 years since the last TBM project," said Frøde Nilsen, managing director of LNS.

Located in northern Norway less than 100km from the Arctic Circle, the Røssåga Hydroelectric Project involves an overhaul and



Assembly of the Robbins TBM in Norway

# INNOVATIVE SOLUTIONS FROM SINGLE UNITS TO COMPLETE SYSTEMS



The Aliva Converto Spraying equipment for hand-operated wet and dry spraying of cement and mortar has a newly developed nozzle for spraying concrete using innovative materials. The Converto is irreplaceable when applying thin or dense stream processes. The concept is modularly based and accommodates all dry and wet application needs. This means that the spraying options are built into the base housing: Converto spraying device, spraying system, Backinlet or ReproFlex.

www.aliva-equipment.com



BUILDING TRUST



**VMT**  
www.vmt-gmbh.de

# 1 mm

The diameter of antennae of the common wasp „Vespula Vulgaris“ and the accuracy of VMT's Active Laser Target Unit.



**UK Government plans new college to train HS2 rail project engineers**

**Great Britain** The UK Government has outlined plans to set up a new college to train the next generation of engineers to work on the construction of the High Speed 2 (HS2) rail project.

The Further Education College is expected to be unveiled by 2017. It will offer the specialised training and qualifications that are needed for the development of HS2 and other infrastructure projects across the country.

The training will be given on making advanced technology and usage of advanced equipment in order to deliver programmes designed specifically for the HS2 project.

The college will also connect with existing academic institutions, private training providers, HE institutions and major supply networks off route.

"It is right that a large-scale investment in bricks and mortar should also come with investment in the elite skills that will help build it," announced business secretary Vince Cable.

During the construction phase, HS2 is expected to create around 2,000 apprentices.

Hitachi Rail Europe will set up a new plant at Newton

Aycliffe, in County Durham, by creating 730 jobs to build Britain made trains.

Hitachi Rail Europe executive chairman and CEO Alistair Dormer said: "As part of our commitment to the UK we are taking on apprentices in all our locations and will be working with a local college to train the engineers, technicians and designers of tomorrow."

**Egis to deliver systems engineering services for Salvador metro**

**Brazil** Build-and-operate concession holder Companhia de Concessões Rodoviárias (CCR) has awarded an engineering contract to Egis for the commercial construction of Salvador metro in Brazil.

The latest contract stems from a concession contract signed between the Brazilian investor CCR and the state of Bahia on 15 October 2013.

The concession contract provides for the city's metro construction and includes a 30-year operating lease.

Under the EUR 12m (USD 16M) contract, Egis will deliver systems management and integration, and interface management between subsystems and civil engineering.

The Salvador metro project includes completion of the partly underground

and nearly 7km Line 1, construction of a line extension by 5km and building of the entire 24km-long east-west Line 2.

Five stations along the stretch of Line 1 are scheduled to enter into revenue service in June for the FIFA World Cup in Brazil.

System installation on the first stretch of Line 1 is currently under advanced stages of construction, while the second line is expected to begin operational service in spring 2017.

MCA, a Brazilian project management subcontractor, has been selected to work with Egis on the contract.

**Eurotunnel signs 10-year mobile services deal with EE and Vodafone**

**Britain** Groupe Eurotunnel signed a 10-year agreement with the British telecom firms EE and Vodafone to offer mobile services in the Channel Tunnel.

With this agreement, Eurostar and Le Shuttle passengers will be able to make and receive mobile phone calls starting in March.

The telecom firms intend to offer 4G data services throughout the tunnel in the near future.

Eurotunnel and its partners have carried out technical work in an effort to provide these services,

which are claimed to be first wireless service below sea level of 100m.

Last year, Eurotunnel signed agreements with the French mobile operators, Bouygues Telecom, Orange and SFR for installation of GSM-P services in the South Running Tunnel.

The move is part of Eurotunnel's plan to continually improve customer service due to rising demand for connectivity on the move.

According to UK-based mobile coverage solutions provider Axell Wireless, consumer mobile services in the Eurotunnel will operate on a separate system to the GSM-R specialist railway communications network that is being enabled using its wireless technology.

The company is using a fibre optic Distributed Antenna System to transmit mobile voice and data signals throughout the tunnel.

"Cellular connections in rail transportation are the future, while wireless coverage is the fourth utility, people expect it as a given, wherever they are," said Ian Brown, CEO of Axell Wireless.

Around 20 million passengers travel through the Channel Tunnel, the world's longest undersea tunnel, every year.

EE was formed after the merger of Orange and T-Mobile in the UK.

# HINDUSTAN CONSTRUCTION TO BUILD RAIL TUNNEL AND TWO BRIDGES

**India** Hindustan Construction (HCC) has received a INR4.42bn (USD 70.8m) contract from railway construction agency IRCON International to build a tunnel and two bridges in Jammu and Kashmir, India.

The project will be between Aprinchala and Sumer stations on the Dharam and Qazigund Section of the Udhampur to Srinagar to Baramulla New Broad Gauge Railway Line Project. It is expected to be completed in 48 months.

HCC will construct a 5.1km-long

tunnel T49A, substructure of 445m-long Bridge 2 and 346m-long Bridge 3 and earthworks at Sumer Yard totalling a roughly 6.4km stretch on Dharam-Qazigund Section of the Jammu and Kashmir rail link.

This project is an extension to a 10.2km-long T48 tunnel currently under construction by HCC between Sumer and Sangaldan stations. The T48 tunnel contract was awarded to the company in September 2012, following the

completion of Pir Panjal Railway tunnel.

The Pir Panjal tunnel between Quazigund and Banihal was inaugurated in July 2013, extending the train service up to Banihal.

IRCON International was chosen to handle the construction of Baramulla to Dharam section of the Udhampur to Srinagar to Baramulla rail link.

The company inaugurated the 119km railway line from Baramulla to Quazigund for public in October 2009.

# BUSINESS OPINIONS

## The Business Insight Community

Set the business agenda by contributing your insight to the community. The Business Opinions Insight Community provides professionals like you with the opportunity to keep up to date with the latest issues and trends being discussed in your industry.

Your views are valued by Business Opinions, which is why we reward you every time you participate. Your contribution is vital.

To join, visit [businessopinions.co.uk](http://businessopinions.co.uk)



**Cranes Today Magazine**

- The independent magazine for the crane industry
- Industry's highest audited circulation of 16,113 (ABC)
- Published 12 times a year
- 100% of requested copies go to named individuals
- 99% of copies reach named readers

**Hoist Magazine**

- Promoting overhead lifting within material handling with an increased end user focus
- Published 10 times a year
- 9,000 printed circulation with 11,000 digital copies
- Hoist remains the only International factory crane magazine

**OCH Magazine**

- Promoting overhead lifting within material handling
- Published six times - Bi-monthly
- Published in America, Mexico and Canada only
- OCH provides a voice for the material handling industry of America
- 10,000 circulation; with 78% reaching industrial end users, 17% reaching distributors and 5% reaching manufacturers



## HIGH QUALITY GASKETS

International Experience – Proven Longevity

**gaskets for precast segmental lining**

- monoepdm
- coexslide
- coexswell
- composite gaskets
- anchored gaskets, mono and combined

for road, railway, metro, cable, sewage and water tunnels

[www.datwyler.com](http://www.datwyler.com)

Sealing Solutions



## FIVE BIDDERS FOR SECOND PHASE OF CALIFORNIA HIGH SPEED RAIL

**USA** The California High-Speed Rail Authority (CHSRA) has received statements of qualifications to build the 60-mile (97km) second phase of high-speed rail from Fresno south to the Tulare-Kern County line near Bakersfield.

After the review of applications, CHSRA will establish a list of the most highly-qualified firms to provide design-build services for the second phase of Construction Project 2-3 (CP 2-3), which is worth between USD1.5bn and USD 2bn.

The five firms that submitted statements of qualifications were California Rail Builders, Dragados/Flatoron/Shimmick, Golden State Rail Partnership,

the Skanska/Ames joint venture and the Tutor Perini/Zachry/Parsons joint venture.

"These five, world-class construction teams represent international interest in helping deliver California's high-speed rail project, a transformative investment in California's future," said Jeff Morales, CHSRA CEO.

The finalised firms will be eligible to submit formal design-build proposals this year. The environmental clearance for the route is expected by summer of 2014.

The proposals will be responsible for providing final designs for bridges, culverts, trenches and tunnels, utility relocations, aerial structures, grade

separations, security and drainage.

Apart from providing thousands of new jobs to the Central Valley, the design-build contract will relieve roadway congestion and encourage economic development. According to the authority, by 2029 high-speed rail will run from San Francisco to the Los Angeles basin within three hours at speeds of more than 200mph (322kmph). The system will eventually extend to Sacramento and San Diego, totaling 800 miles (1,287 km) with up to 24 stations.

CHSRA awarded a design-build contract for Construction Package 1 in June 2013.

### Arcadis JV secures consulting contract on Santiago Metro

**Chile** Dutch infrastructure firm Arcadis in a joint venture with WorleyParsons has won a USD 11m contract to provide engineering consulting services for the design of the stations of Line 3 of the Santiago Metro in Chile, which will be operational in 2018. It will also be involved in all stages of Line 3.

A team of 40 people will work for Arcadis on the project that will intersect with almost all current metro lines. Santiago Metro is seeking a design that addresses the interaction with existing lines through tunnels and stations.

The project is part of the Urban Transport Investment Plan in Santiago that involves expansion of the Metro's 100km network to 140km.

Under the contract, Arcadis will perform detailed engineering of all the stations for Line 3, a 22km line with 18 new stations, and generating all the plans and tender documents. Furthermore, Arcadis will also deliver architecture, structures, tunnels, electrical and mechanical engineering.

The contract will have a

timeline of 18 months for design and three years for construction supervision.

Arcadis Chile CEO Hernan Bezamat said: "Adding to the complexity of the project is the need to tunnel under one of the most densely populated cities in the country. Arcadis thrives on challenging projects like these where we can showcase our engineering expertise while balancing the needs of growing communities with minimal impacts to the environment."

### Chicago's CTA announces Blue Line upgrade project

**USA** The Chicago Transit Authority's (CTA) Blue Line O'Hare Branch is set to undergo a USD 492M four-year overhaul programme to provide faster, improved, comfortable and more reliable commutes.

Announced by mayor Rahm Emanuel and Illinois governor Pat Quinn, the Blue Line investment plan will involve upgrading several tracks, signal systems and stations along the 12.5-mile (20km) Blue Line.

Mayor Emanuel said: "Like the Red Line South project we just completed on time

and within budget, this Blue Line plan is far-reaching and long overdue, and will help meet increasing demand."

Currently, more than 80,000 customers use stations along the branch each weekday.

Over the past five years weekday ridership on the O'Hare Branch increased by 25 per cent.

As part of the more than USD 4bn transit improvements announced by Emanuel in 2011, the Blue Line plan funding will be provided by local, state and federal sources.

Upgrades to the tracks are intended to remove and prevent slow zones in the Milwaukee Subway from Damen to Belmont and Dearborn Subway from Grand to Division, respectively.

Improvements to the track near the O'Hare station and in the Rosemont rail yard will aim to reduce delays and for efficient operations.

The stations that will undergo renovation include Grand, Chicago, Division, Damen, California, Logan Square and Jefferson Park.

Repairs will be carried out at the Irving Park, Montrose, Harlem and Cumberland stations, as well.

In the subway tunnels,

wireless infrastructure will be modernised to provide faster and more reliable voice, data and web service to customers and workers in the subway.

While the project schedules are yet to be finalised, work will start with track work this year followed by station renovations, power upgrades and signal improvements.

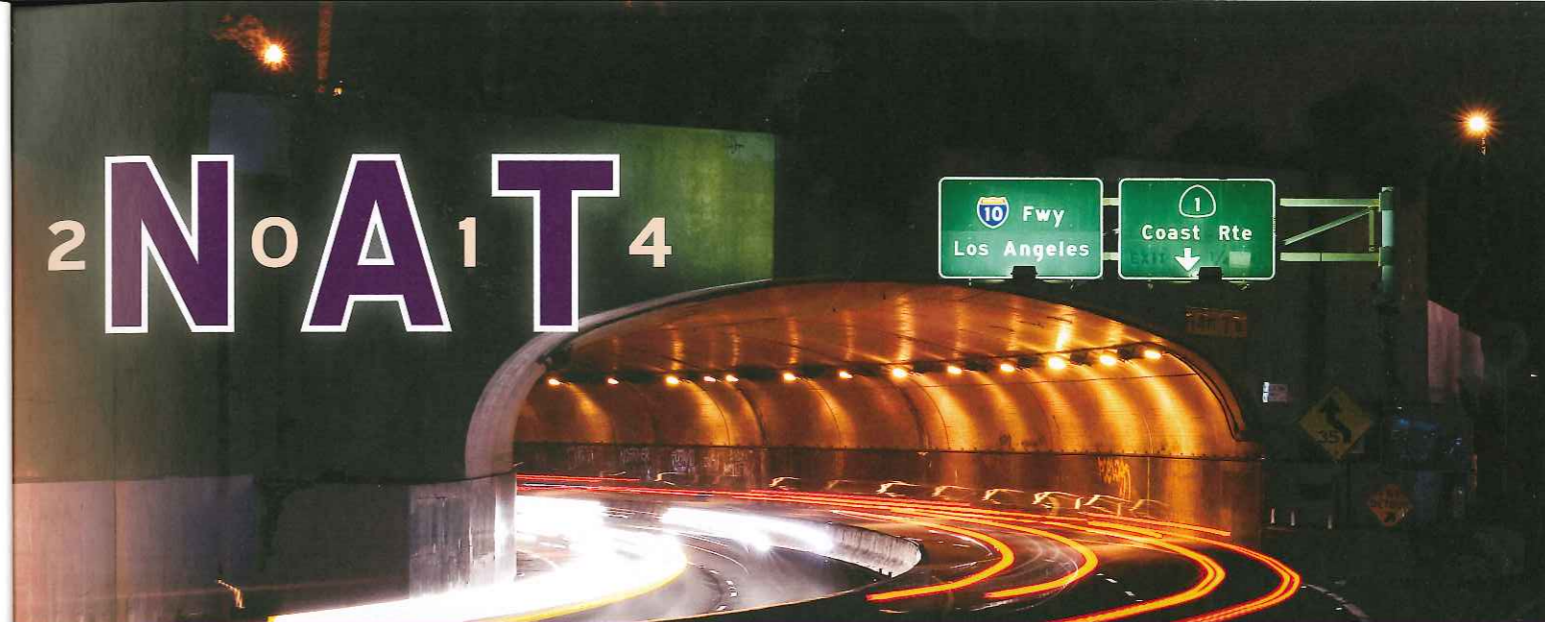
### Raise borer advances at South American mining project

**Argentina** Terratec's Raise Boring Machine, TR2000, began operations at a mine site in Santa Cruz, Argentina in September 2013, the company announced recently.

In the last three months the TR2000 completed five shafts with lengths varying from 100m to 200m and with reaming diameter of 1.8m and 2.1m.

Each raise was completed in a time between eight and 13 working days, including both the pilot hole and the reaming, Terratec announced.

The TR2000 achieved peaks of advance between 15m and 17m in one single shift of 10 hours on each of the five shafts, which has set a production record in the history of the mine.



## MARK YOUR CALENDAR

### TUNNELING: MISSION POSSIBLE

June 22-25, 2014 • JW Marriott • Los Angeles, CA, USA

#### THE PROGRAM WILL INCLUDE:

- Tunnel Boring Machines
- Ground Conditioning & Modification
- Equipment Automation
- Conventional Tunneling
- NATM/SEM
- Caverns
- Small Diameter Tunneling
- Shaft Construction
- Emerging Technologies
- Risk Management
- Tunnel Lining Design and Precast Segment Advances
- Fire & Life Safety
- Vulnerability & Security
- Rehabilitation
- Cost Estimating & Scheduling
- Design & Planning
- Contracting & Payment
- Alternative Delivery Methods
- Financing, Insurance & Bonding
- Third Party Liability
- Labor Management & Training
- Case Histories
- Future Projects

The meeting will also feature short courses, field trips, exhibits, networking and more!

#### NAT

Online: [www.smenet.org](http://www.smenet.org)  
(under the Meetings tab for NAT)

#### SME

12999 E. Adam Aircraft Circle  
Englewood, CO 80112

For additional information on exhibiting, sponsorship or general inquiries, contact

SME, Meetings Dept.  
Phone: 303-948-4200  
[meetings@smenet.org](mailto:meetings@smenet.org)  
[www.smenet.org](http://www.smenet.org)

**Black River Tunnel project launches TBM**

**USA** Launch for the 1.6 km Black River Tunnel in Lorain, Ohio, took place on November 18, 2013, TBM manufacturer Robbins announced last month.

A 7m diameter Robbins Double Shield TBM and continuous conveyor system are being used for tunnel excavation. The TBM was built using Onsite First Time Assembly (OFTA)—a Robbins-developed method.

"OFTA was a challenging process for everyone onsite," said Mike Garbeth, project manager for Wisconsin-based contractor Super Excavators, Inc. "We had to make numerous adjustments. Regardless, our team worked diligently to overcome challenges, and we were able to get the TBM assembled and launched relatively close to schedule."

The Double Shield machine will be used in a unique manner as it bores

"We're expecting decent production with minimal cutter wear, as the drive is in a softer shale," said Gregg Rehak, tunnel supervisor for Super Excavators. "We are installing ring beams and lagging, and there will be a final monolithic pour after tunnel completion."

Rather than concrete segments, ring beams are being erected within the tail shield for installation as the machine passes.

As of December 2013, the machine had advanced approximately 60m into the bore.

"Tunneling started a bit slow while we made final adjustments to the TBM and conveyor assembly, but mining has picked up and we are beginning to reach anticipated production rates," Garbeth said.

The major components of the Black River Tunnel include the launch shaft and reception shaft – approximately 11m in diameter and 50m deep –

and a 1.7km tunnel with a finished diameter of 5.8m. Ric-Man Construction was subcontracted to build the shafts.

The project route runs along city property roughly parallel to the Black River, beginning at the launch shaft near the Black River Wharf and terminating near the Lorain Black River Wastewater Treatment Plant.

Mining is expected to be completed by spring and final project completion is set for 2015.

When finished, the tunnel will have a storage capacity of 42 million litres per day, providing a significant boost in water quality for the city of Lorain.

**British Tunnelling Society to launch new look website**

**Great Britain** The British Tunnelling Society (BTS) was due to launch a new website as *Tunnels* went to press. The revamp was due to go live online at the end of January.

The new site, as well as being laid out in a clearer, easy to navigate manner, is significantly expanded, and is designed for future expansion.

A few key changes announced by the BTS included:

- Notices of evening meetings and conferences are provided with calendar items and links to meeting video recordings
- The website contains a search facility
- The BTSYM have a section of the new BTS website, and the BTS and BTSYM sites are now combined, providing uniformity of design

- The website contains a secure web booking and payment system, allowing secure transactions relating to events and courses, such as the annual BTS dinner
- A 'members only' area will follow later this year – allowing the BTS to load additional information which can be restricted to Members only

- A file sharing area where the BTS Committee, Subcommittees, and Working Groups can share files and work together on a common document
- The database of UK tunnels, which was attached to the old website, is now out of date, and the database is currently being reconstructed to provide additional information, an improved search facility, and to allow for input from projects

The re-design has been carried out by the website subcommittee under the direction of Ken Spiby of London Bridge Associates, who defined the new structure and input much of the content.

The subcommittee also moved to change website provider to the Commercial Applications Company, which designed and built the new site, and going forward will have direct control over the input of content (cutting out a third party delay in updating).

This has also resulted in a significant saving for the BTS in annual service and maintenance costs.

Spiby added, "The old BTS website had not seen any significant changes for around 10 years, and its structure had been restricting the ability for the BTS to increase functionality."

"And so the BTS Committee decided that it was time to start again and build a modern looking website with additional functionality and flexibility built in."

"The BTS committee and website subcommittee would welcome any feedback on the new site, and on any further functionality or information that our members would like to see on it."

A BTS spokesman added, "The BTS would like to express their thanks to Ken Spiby, Chair of the website subcommittee for his work in leading the creation and population of the new website."

SOFRASAR TUNNEL PRODUCTS **ANIXTER**

FASTENERS and LINKS for TUNNEL SEGMENTS



With an extensive range of applications including dowel, bolting and injection systems, anchors and accessories, we are specialists in the provision of a complete and innovative range of links and fasteners for tunnel segments.

**MORE THAN PRODUCTS, WE SUPPLY SOLUTIONS**

**ANIXTER Fasteners France**  
 ☎ : +33 (0)3 87 28 50 85  
 ✉ : tunnel@anixter.com  
 🌐 : www.anixterfasteners.fr

**FOR SALE**

- 1 TBM ROBBINS hard-rock, Ø 5.08 – 5.20 m, Jarva MK 15
- 1 TBM ROBBINS hard-rock, Ø 3.50 m, Alpine Westfalia
- 1 TBM HERRENKNECHT, Type S-96, Ø 2.83 – 3.60 m, Year 1996
- 1 Roadheader WESTFALIA, Type FL-3R-33
- 1 Excavator LIEBHERR, Type 934 T, Year 2004
- 1 Dumper PAUS, Type ITC 10'000, Year 2007
- 3 Lifting Platforms mounted on ATLAS Excavator
- 1 Scissors Lifting Platform mounted on SAURER Truck
- 8 Battery Locomotives SIG ATS 100 / ETB 70
- 2 DIESEL Locomotives SCHÖMA CFL 200, Track 900 mm
- 2 DIESEL Locomotives SCHÖMA CFL 180, Track 900 mm
- 2 DIESEL Locomotive HUDSON, 22 to, Track 750 mm
- 1 DIESEL Locomotive GIA DHD 35, Track 750 / 900 mm
- 2 Mining Cars HÄGGLUND HRST 115CE
- 1 HÄGGLOADER 8 HR, EL 37 kW, Track 750 mm
- 2 Fans KORFMANN, Type AL 10 / AL 17 FU
- 1 Drill Rig ATLAS 477, Track 750 mm
- 2 LHD Loaders GHH LF 12 / SANDVIK 307
- Pipeline Tubes with VICTAULIC Couplings 2" / 3" / 4" / 6" / 8" / 10" / 12"
- 10'000 m Rails of Profile 93/ 100/ 130/ 140 mm
- California Switch on Request
- 1 Tunnel Conveyor, Length 4'100 m, Width 1'200 mm
- 1 Conveyor Belt, Length 500 m, Width 650 mm
- 2 Impact Roll Crushers HAZEMAG, Type SB 1315

**SCHLATTER PETER AG**

Stollenbaumaterial/Pipelines/Armaturen  
 CH – 5084 Rheinsulz  
 Tel. +41 (0)62 874 32 02  
 Fax +41 (0)62 874 32 12  
 info@schlatter-peter-ag.ch  
 www.schlatter-peter-ag.ch



**CTE SENDS KUALA LUMPUR TBM**

**Malaysia** Following the successful factory acceptance test of the first TBM bound for the Kuala Lumpur MRT, CREC-TBM are pleased to announce the launch of their new International Division, CTE Limited.

The TBMs being supplied are 6.67m EPBM and will be used to construct part of the new metro line in Kuala Lumpur. They are built to a high specification and conform to the usual international standards such as BS6164 and EN 12336.

Many of the key components for these machines have been purchased from European suppliers, such as the main bearing, drive motors, gear reducers, hydraulic components and the Electric/PLC components.

CTE Ltd has been established, in Hong Kong, with the sole purpose of marketing and presenting the TBM manufactured by CREC-TBM, and to provide full support to users of CREC-TBM machines in terms of Field Service and after sales activities.

Don Hall has been appointed as CTE managing director and will initially be based in the Kuala Lumpur office. CTE will comprise several internationally experienced tunnelling professionals.

In addition to TBM's CREC-TBM can supply certain items of auxiliary equipment such as rolling stock, including, both diesel and electric locomotives up to 50T in weight, tunnel formwork and piling rigs. Through CTE Ltd, this capability is now available to customers outside China.

tunnelsoft

**The All-in-One Solution**

TPC TPC ST

[www.tunnelsoft.com](http://www.tunnelsoft.com)

**BABENDERERDE ENGINEERS**

**Tunnelling Services world-wide**



- Construction Management
- Engineering / Consulting
- Trouble Shooting
- Project Development

[www.babeng.com](http://www.babeng.com)

Share tracker

Company	November	December	Change (%)
Aecom (NYSE: ACM)	28.96	27.8	▼ 1.16 (4.01)
Atkins (LSE: ATK)	1,251	1,348	▲ 97 (7.75)
Balfour Beatty (LSE: BBY)	274.5	262	▼ 12.5 (4.55)
BASF Global (XETRA: BAS)	76.09	73.94	▼ 2.15 (2.82)
Bekaert (BSE: BEKB)	29.47	25.13	▼ 4.34 (14.73)
Bilfinger Berger (DUS: GBF)	81.56	79.69	▼ 1.87 (2.29)
Costain Group (LSE: COST)	294	279	▼ 15 (5.10)
Ferrovial (MCE: FER)	13.99	13.35	▼ 0.64 (4.57)
Hindustan Construction Company (BOM: HCC)	13.6	13.55	▼ 0.05 (0.37)
Hochtief (XETRA: HOT)	66.02	59.05	▼ 6.97 (10.56)
Leighton Holdings (ASX:LEI)	17.62	15.09	▼ 2.53 (14.35)
Morgan Sindall (LSE: MGNS)	839.5	753	▼ 86.5 (10.30)
Sandvik (STO: SAND)	90.75	85	▼ 5.75 (6.34)
Shanghai Tunnel Engineering (SHA: 600820)	8.45	9.19	▲ 0.74 (8.76)
Strabag (LSE: STR)	20.96	20.61	▼ 0.35 (1.67)
URS Corporation (NYSE: URS)	51.56	50.74	▼ 0.82 (1.59)
Vinci (EPA: DG)	46.88	45.65	▼ 1.23 (2.62)

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

**Balfour Beatty sells Scandinavian rail business**

**Great Britain** UK-based infrastructure group Balfour Beatty has reached an agreement to sell its Scandinavian Rail business including all current operations in Sweden and Denmark to Strukton Rail for a cash consideration of about GBP 4M (USD 6.59M).

With this acquisition, Strukton Rail has strengthened its geographical presence within the railway industry in Sweden and Denmark. Currently, Strukton Rail is executing major projects in Scandinavia for the Citybanan in Stockholm and the S-Bane in Copenhagen. Strukton is also responsible for the maintenance of various railway lines in Sweden.

Balfour Beatty Rail Scandinavia is involved in the installation of the ETCS infrastructure across the Fjernbane West and East lines in Denmark.

Strukton Rail Scandinavia managing director Robert

Röder said: "Strukton Rail and Balfour Beatty Rail Scandinavia have been active in the same Scandinavian market for a long time. We share knowledge and expertise, but we also complement each other within some technique areas. Under a common flag we will be able to offer our customers a strong and broad range of services and products, with the aim to be one of the foremost suppliers in the rail sector in Sweden and Denmark."

Balfour Beatty CEO Andrew McNaughton said: "I am very pleased that we have continued to execute on our stated strategy of disposing of our mainland European rail businesses."

"We have found a good home for the business, its customers and employees, and we continue to explore similar options for our remaining mainland European businesses."

In 2011, both the companies partnered to maintain the Stambanan in Norrland (North of Sweden).

The transaction, which has

been permitted by Swedish Competition Authority, is expected to close this year.

**Transurban to purchase tunnel debt**

**Australia** Transurban has purchased AUD 475M (USD 418M) of debt held by Sydney's Cross City Tunnel (CCT) in Australia.

The 2.1km twin tunnels connecting Sydney, east and west, went into receivership in September 2013 after a legal dispute with the New South Wales government over stamp duty.

In November 2013, Transurban agreed to buy all of the toll road's senior debt from the Royal Bank of Scotland, as it looked to take control of the tunnel.

CCT has the concession to toll and operate dual 2.1km twin tunnels linking Darling Harbour on the western fringe of the Sydney CBD to Rushcutters Bay in the city's eastern suburbs.

The motorway commenced operations in 2005 under a concession expiring in December 2035. CCT is linked

Central bank rates

	Rate (%)
AUD	2.50
BRL	10.50
CAD	1.00
CHF	0.25
CNY	6.00
EUR	0.25
GBP	0.50
INR	8.00
JPY	0.10
NZD	2.50
USD	0.25

Rates are taken on the 12th of each month.

to the Eastern Distributor owned by Airport Motorway Group (AMG -- A3 stable), which is in turn 75.1 per cent owned by Transurban.

Transurban is a developer and operator of toll roads under long-term concessions, predominantly in Australia. Its key assets are the Melbourne CityLink Tollroad, M2 Hills Motorway, Lane Cove Tunnel as well as 50 per cent of the Westlink M7 Toll Road. Transurban also owns 75.1 per cent of AMG, and 50 per cent of Interlink Roads Pty Limited (A2 stable), the concessionaire for Sydney's M5 South West Motorway.

**Leighton to purchase Welspun Group's stake in Indian JV**

**India** Leighton Holdings announced it has agreed to purchase the Welspun Group's 39.9 per cent stake in its India-based joint venture, Leighton Welspun, for USD 99M to achieve 100 per cent ownership.

The opportunity arose from the decision by Welspun to reposition its infrastructure business and to focus on its core businesses (including pipes, energy and steel).

Leighton will rename the business Leighton India. It will continue to report through Leighton Asia, India and Offshore (LAIO)

under Ian Edwards, LAIO's managing director.

The joint venture, established in 2010, aimed to provide a strategic partnership that could capitalise on opportunities in the Indian infrastructure sector especially Public Private Partnerships.

Leighton continues to see strong long-term prospects in the Indian market.

As a part of the business transformation program currently under way across the group, LAIO will take the opportunity provided by the move to 100 per cent control of Leighton India to undertake a review of its operations and consider integrating several business units to both lower costs and provide greater business opportunities, the group announced.

Leighton's business transformation program – encompassing working capital management; global business services; strategic procurement; management structures; and group asset management – aims to strengthen the group's

balance sheet, improve efficiency and lower costs.

The transaction will be recognised in fiscal year 2013 and have a negative impact of approximately AUD 70M (USD 61.6M) on net profit after tax. This arises as a result of reclassifying the joint venture's foreign currency translation reserve from equity to profit and loss in accordance with Australian Accounting Standards.

Leighton's 2013 underlying net profit after tax will not be impacted by this transaction and the forecast remains in the range of AUD 520M (USD 458M) to AUD 600M (USD 528M). The transaction will complete in the first quarter of 2014 once the procedural conditions are completed.

**Burke elected Aecom CEO**

**USA** Effective March 6 Aecom president Michael Burke will succeed John Dionisio CEO, as part of a planned succession process, Aecom announced last month.

Dionisio will become

executive chairman of the board of directors when Burke succeeds him as CEO, and joins Aecom's board.

"On behalf of Aecom's board of directors, I am pleased to announce Mike's appointment as CEO," said Dionisio.

"As president, and in his previous role as CFO, Mike has worked closely with me to shape and drive Aecom's growth strategy, diversify our service offerings, expand our global footprint and deliver superior business results."

"This seamless transition is part of our planned succession process, which enables Aecom to continue to execute our enterprise strategy, while maintaining our commitment to delivering innovative solutions to our clients around the world."

Burke joined Aecom in 2005 and was named chief financial officer in 2006. He was appointed president of Aecom in October 2011 and has played a key role in the company's ability to double its workforce, triple its revenue and dramatically expand its technical capabilities and geographic reach during his tenure, the company announced.

"I am extremely honored to lead Aecom and am grateful to John and the board of directors for the privilege to lead the 45,000

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



editor@tunnelsonline.info

AECOM architects, engineers, designers, planners, scientists and management professionals who serve our clients around the world," said Burke.

"I look forward to working with our talented management team to leverage Aecom's strengths and leadership in technical excellence, innovation and project delivery to provide world-class service to our clients, professional development opportunities to our staff and incremental value to our stockholders."

Dionisio has been with Aecom since 1971. In 2005, he was named president and CEO, and in 2011 he was named chairman of the board. In order to assist Burke and the company's board of directors through the transition, Dionisio has agreed to serve as executive chairman until March 2015.

News briefs

**SWITZERLAND**

Aldo Ceresola, who has some 20 years of experience in underground construction, will join Bekaert's Swiss Dramix team. After introduction to the Swiss market Aldo will be responsible for all tunnelling activities in Switzerland.

**GLOBAL**

Updating is underway for Tunnels & Tunnelling Buyer's Guide 2014 and the hugely successful online version www.tunnels-directory.co.uk. So make sure you don't miss the opportunity to put your products and services in front of a guaranteed, targeted audience of tunnel engineering professionals throughout the global tunneling market when they are searching for information on suppliers!

In the last 12 months over 16,000 buyers have made nearly 275,000 visits to the site to contact new suppliers and companies with enhanced entries have seen a significant increase in the number of enquiries they have received.

If you act now your company will also be included in the 2014 printed edition which is sent to all subscribers of Tunnels & Tunnelling International.

To ensure your company doesn't miss on the opportunity to generate new enquiries for the next 12 months please call +44 1892 771047 or email tun@boundarymedia.co.uk

Oil price



106.3  
November 2013

109.0  
December 2013

Values are taken on 12th of each month.



## FIRST VFD BREAKTHROUGH

The Klang Valley MRT Project celebrated the breakthrough of the world's first Variable Density TBM on January 9, used for the MRT Sungai Buloh-Kajang Line.

The TBM launched from the Cochrane Launch Shaft in Cheras on 22 July 2013. It excavated a distance of around 1km through limestone formation to complete the tunnel at the Pasar Rakyat Station.

The breakthrough marks the completion of the first section of twin tunnels (between Cochrane and Pasar Rakyat Station) for the 9.5km MRT Sungai Buloh-Kajang Line underground alignment without any major issues.

The variable density TBM is the first of its kind, designed and jointly developed by the MRT Project's underground works contractor, MMC Gamuda KVMRT (T) Sdn Bhd and Herrenknecht, specifically for tunnelling in Kuala Lumpur, which is extremely challenging as the city is built above two different geological formations.

In the western part of the city is the Kenny Hill Formation which is more consistent and easier to tunnel through. In the eastern part however lies the Kuala Lumpur Limestone geological formation, which poses many uncertainties and challenges. This is because the formation consists of hard rock with soft overlying, as well as void chambers and cavities which cannot be easily identified. The variable density TBM is specially designed to handle excavation through the transition between the two geological formations, as well as to overcome the challenges posed by tunnelling through the karstic nature of the Kuala Lumpur Limestone Formation.

# INDIA

## INVENTORY

Danny Richards, senior economist for the data and market analysis arm of Tunnels' publisher, *Timetric*, presents this report forecasting the economic performance of India's infrastructure construction industry forward to 2017, extrapolated from a focus period 2008-2012

**B**Y THE end of the review period (2008-2012) the Indian construction industry hit a total value of INR 22tn (USD 409bn). The country's expanding economy, increased government spending on public infrastructure, and a supportive foreign direct investment (FDI) system aided the growth.

### DOUBLING UP

Construction industry growth is expected to remain strong over the forecast period (present to 2017), as a result of the government's commitment to improving the country's infrastructure. The industry's output is expected to record compound annual growth of 15.45 per cent over the forecast period and double in value to INR 45.1tn (USD 838bn) by 2017. ▶



*Danny Richards*

Danny is an economist at Timetric, the market analysis arm of *Tunnels* publisher WMI

**WTC  
BRAZIL 2014**

**WORLD TUNNEL  
CONGRESS 2014  
40<sup>th</sup> ITA-AITES  
GENERAL ASSEMBLY**

May 9<sup>th</sup> to 15<sup>th</sup>, 2014  
Iguassu Falls - Brazil

**WTC 2014 WILL  
BE FOR SURE  
A GREAT  
SUCCESS!**

- More than 550 abstracts have been received, exceeding the expectations. Strong indication of successful congress.
- To make on-line registration, access the official Congress website. Be a part of it by making yours.
- Technical exhibit: very limited number of booths still available

**More information:  
[www.wtc2014.com.br](http://www.wtc2014.com.br)**

Promotion



Institutional support



Infrastructure construction is the largest market in the construction industry, accounting for a 32.9 per cent share of the total value in 2012. During the review period, the infrastructure market grew at a compound annual rate of 16.84 per cent to reach a value of INR 7.2tn (USD 134.5bn) in 2012. India invested heavily in infrastructure construction projects during this time and is anticipated to continue to invest over the forecast period. The infrastructure construction market is expected to grow at 17.18 per cent over the forecast period, driven primarily by energy, rail, and road sectors.

India's real GDP growth fell from 9.3 per cent in 2010/2011 to 6.2 per cent in the 2011/12, and fell further to 5.1 per cent in 2012/13. This is primarily due to declining investments, soaring inflation, high interest rates and sluggish external demand.

India's economic growth is estimated to have slowed to 5.1 per cent in 2012/13, the lowest rate in a decade. This was caused by inadequate infrastructure, sluggish investment growth and policy paralysis. It is expected to improve marginally in 2013/14. However, with a possibility of recovery in global economic growth and an expected improvement in business sentiment, India's GDP growth is expected to improve in the following three years and will expand between 6 per cent and 7.5 per cent a year.

#### FUNDING

The general outlook for construction activity during the five-year forecast period is positive. Investment in physical infrastructure will also be a major driver of construction growth, with various infrastructure projects in the pipeline nationwide. The government expressed plans to invest INR 55tn (USD 1tn) in various long-term development plans under the 12th five-year plan (2012–2017). However, given the government's fiscal challenges, much depends on the extent to which it can involve the private sector in these projects. More still needs to be done to improve the regulatory environment pertaining to construction projects to facilitate faster private investment growth. According to the World Bank's Doing Business survey, India ranked 181st out of 183 countries in the category of dealing with construction permits.

In order to meet the long term need of infrastructure construction funding, a Memorandum of Understanding (MOU) for setting up India's first infrastructure debt fund (IDF) was signed by ICICI



Group, Bank of Baroda, Citicorp Finance India and Life Insurance Corporation in 2012. IDF will provide an alternative source of finance for investors and allow more investment in the infrastructure construction market. It aims to attract private investment to finance the majority of infrastructure projects. Major investments will be made in public-private projects on highways, railways, ports, roads and other infrastructure projects.

**BARRIERS TO ENTRY - LOW**

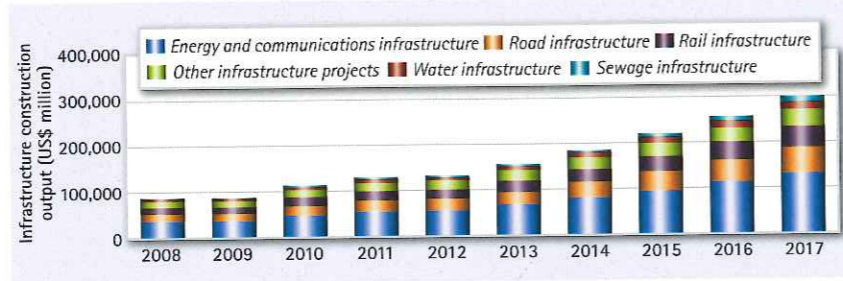
The barriers to entry for contractors in the Indian construction industry can be categorized as low. The country's economic structure is focused on the liberalization of regulations for establishing new firms.

The government is expected to implement more business-focused reforms over the forecast period. The World Bank's Doing Business 2013 report ranks India 132nd out of 185 global economies. The country's 'Dealing with Construction Permits' rank improved from 183 in 2012 to 182 in 2013, while the 'Registering Property' rank improved three places to reach 94 in 2013. Only 12 procedures and 27 days are required to establish a business. Substantial opportunities for new and innovative construction projects in the country also reduce the barriers for entry.

**INFRASTRUCTURE PERFORMANCE**

Energy and communications infrastructure construction is expected to record healthy growth over the forecast period, with an expected CAGR of 17.97 per cent. Output in this category stood at INR 3.2tn (USD 58.7bn) in 2012, having grown at a CAGR of 17.23 per cent during the review period. Owing to high industrialisation, urbanisation and a rising population, electricity demand in India is rising. In a bid to maintain the balance between supply and demand, the government announced, in their 12th five-year plan, an aim to achieve 90GW of additional installed capacity by 2017.

Road infrastructure construction was the second-largest category in the infrastructure construction market during the review period and valued INR 1.3tn (USD 24.2bn) in 2012. The category grew at a CAGR of 17.78% during the review period and is expected to record a CAGR of 17.53 per cent during the forecast period. In October 2012, the government approved a total of INR 15bn for highway projects under phase IV of the National Highway



Above: Figure 1, Growth in various infrastructure sectors to 2017

Development Program (NHDP).

With a value of INR 1.1tn (USD 19.9bn) and a share of 14.8 per cent in 2012, rail infrastructure construction was the third-largest category in the infrastructure construction market during the review period.

The category is expected to expand at a CAGR of 17.72 per cent over the forecast period. A sharp increase in passenger traffic means Indian rail infrastructure needs to be enhanced. In the 2013 rail budget, Indian Railways announced their plan to invest INR 63.4bn (USD 11.5bn) on rail infrastructure during 2013-2014.

**KEY ISSUES**

Infrastructure investment is pivotal to supporting long-term economic development. In a bid to improve the nation's infrastructure and attract more foreign investment into the country, the government announced its plan to invest INR 55tn (USD 1tn) for infrastructure construction in the 12th five-year plan (2012-2017).

Owing to implementation of the NHDP programs, which support the active participation of the private sector in public construction projects, India recorded healthy growth in infrastructure projects. A total of USD 38bn in build, operate and transfer (BOT) concession contracts, which were awarded in December 2012, are projected to be fully operational by 2015-2016.

At the end of the 12th five-year plan, total renewable energy generation capacity is expected to have increased by 30GW to 55GW. The renewable energy infrastructure will be further fueled by a six-year EUR 1bn (USD 1.3bn) loan from Germany.

**IN THIS ISSUE**

In this issue, *Tunnels* looks presents three articles from the Asian Subcontinent:

- In the wake of devastating floods in northern India last June, environmentalists have accused hydropower infrastructure of causing a man-made disaster. On p.28, Mahendra Bisaria of Gammon Infrastructure defends the use of hydropower by exploring the Himalayan region's geology and the development process for such projects. The Geological Survey of India completed its report in January, along with a number of engineering recommendations to stabilise the region.
- Engineers from Ayesa take a brief look on p.35 at the detailed design for construction of NATM tunnels on the Ovulavaripalle to Venkatachalam railway line in Andhra Pradesh, India.
- On page 40, *Tunnels* takes a look at the experiences of TBM manufacturer Terratec working across several sites on Phase III of the Delhi Metro. Site setups, land acquisitions and other local complications are a challenge for the impressive project, as a polluted and overcrowded city throws world-beating investment into its infrastructure solutions.



Timetric is a leading business information service, providing financial and economic research services based on proprietary data

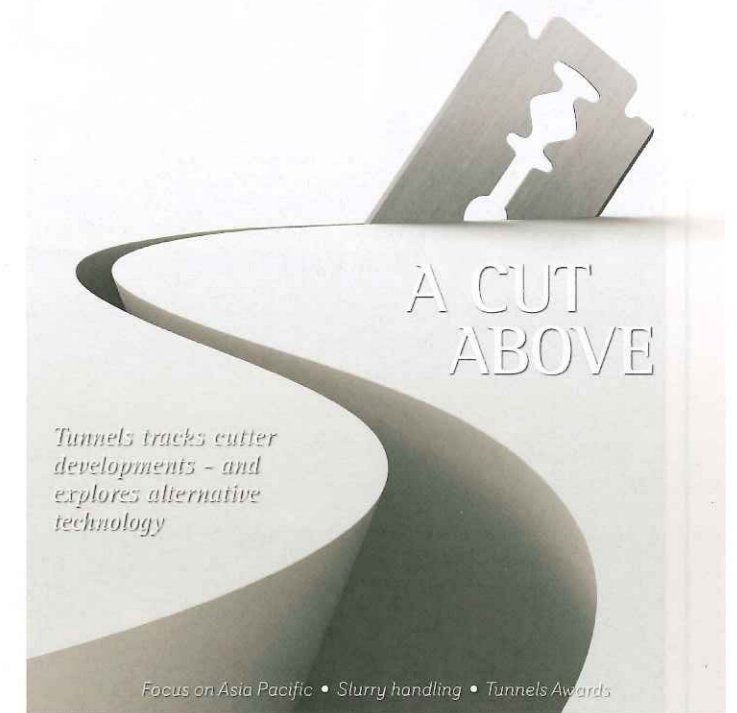
# Tunnels

AND TUNNELLING

The leading tunnelling magazine for 42 years!

Don't miss out on your monthly copy of *Tunnels*

- Continues to hold the highest reputation of any magazine in the field of tunnelling
- The dedicated international monthly magazine, distributed in more than 107 countries
- Keeping today's tunnelling professionals informed and ahead



For each new subscription we donate 10% to RedR, an international disaster relief charity

To subscribe, call our subscription hotline on: +44 (0) 845 155 1845 or visit us on: [www.tunnelsonline.info](http://www.tunnelsonline.info). When subscribing, please quote: TUN2013





In the wake of devastating floods in northern India last June, environmentalists have accused hydropower infrastructure of causing a man-made disaster. Mahendra Bisaria, of Gammon Infrastructure, defends the use of hydropower by exploring the region's geology and the development process for such projects

**M**Y HEART goes out to the families who have lost their dear ones during the recent unprecedented devastation in the north Indian state of Uttarakhand. The author is also saddened to see the damage to the landscape around the river systems, including private and public properties and infrastructure projects. The author has worked in the area and was there visiting projects during this very period a decade ago. It is going to take a long time to make a real assessment of the loss.

As is natural, people announce their snap judgements regarding the causes of this tragedy and question if the losses could have been mitigated--some out of extreme anger while others to demonstrate that their apprehensions have come true. It is intended for this article to explore the situation in a holistic manner without any bias.

It has to be well understood that the very formation of the Himalayas is entirely different than other mountains. They have been formed by the crust of the earth folding under great pressure resulting from the movement of the Indian Plate against the Tibetan Plateau. Consequently, the rocks are as varying as the crust of the earth that has gone into the formation of Himalayas. The Himalayan rocks are under great stress due to the folding. The stresses get

*Left: Thousands died in the June 2013 floods, and many locals and tourists were left stranded*

**Mahendra Bisaria**  
Mahendra is a management consultant at Gammon Infrastructure in Mumbai.



released now and then causing minor or major earthquakes and in the slippage of rock mass along faults, shear zones or other geological weaknesses. With excessive rain, the rock mass gets saturated and additional slippages, small and large, occur.

Historically, large slips have been occurring in the Himalayas either due to excessive rainfall or due to earthquakes. The great earthquake of 1950 caused immense damage to the Brahmaputra Valley in the North Eastern Himalayas. At this time, no hydro electric projects had been constructed. The damages in the Brahmaputra Valley and the river itself were unprecedented with the bed rising above bank levels at several places. Huge cracks capable of swallowing elephants had developed in the river bed. Then Prime Minister, Pandit Jawahar Lal Nehru, had rushed to Dibrugarh and called for the Flood Protection Embankment to be constructed for the safety of Dibrugarh before the next floods. The work was accomplished by the Central Water Commission. The extreme turmoil, into which the river Brahmaputra was thrown, resulted in its behaving as a braiding river that has yet to settle down.

A very large slip in the Alaknanda Valley in 1970 caused heavy silt content in the discharge of the Ganga. Again, there were no hydro electric projects in the Ganga Valley at that time. There was hardly any addition to the existing roads. Improvements to the Delhi- Badrinath road, making it a national highway, came much later. Also, there was not any

**"The damages in the Brahmaputra Valley and the river itself were unprecedented with the bed rising above bank levels at several places."**

notable encroachment in the waterway of the riverine system and so only a little damage to the property occurred. The Upper Ganga Canal taking off from the Ganga at Haridwar was then the first Water Resources Project. Heavy siltation occurred in the Ganga Canal for several kilometres in the head reach, which had to be cleared well before the ensuing Rabi Irrigation. As the author was associated with the work, the author recalls what a massive project it was to be completed in a short period in those times. With that experience, the Ganga Canal was closed this time to avoid a repeat of the same.

In 1978, there were record damages due to floods all over the country. Most of the bridges across the river Teesta in Sikkim were washed away. There were no hydro power projects then on Teesta or its tributaries. The same year, there was a very large slip in the Bhagirathi valley near Bhatwari, much upstream of Uttarkashi and the then under-construction Maneri Bhali Hydro Electric Project Stage I, where the author was working. The slip caused a blockage of the river and water started getting impounded. A few days later when the blockage was washed off, huge discharge with a high wall of water gushed down causing damage to both the project and the town of Uttarkashi.

Himalayas not only have the maximum of water potential in the country but also have a maximum of hydro power potential. The growing needs of the society call for larger availability of energy, both for domestic and industrial usage. There are two types of sources of energy: ones that are capable of being replenished like hydro, wind, solar, etc., and the others that are limited, like coal, crude oil, gas, etc.

Thus far, among the former, hydro power is the most exploited source of energy, and for which our country has maximum of unexploited potential in the Himalayas.

Construction of hydro power projects in the Himalayas

*Below: Excessive rainfall can cause slippages in the Himalayas*

continues to be, wrongly or rightly, labelled as responsible for the damages in the area, both to the society and to the topography. There can be endless arguments for and against this thinking. However, in the wake of the recent disaster in Uttarakhand, it is proposed to examine the existing practices and possible improvement.

Hydro power as a source of energy is a necessity for society for reasons that it causes no or minimal damage to the environment. Even though it is capital intensive and has long gestation, it is still much cheaper than other sources. Commercially, also, it may not be prudent for the states having this potential, not to tap it. Otherwise, for India it shall mean a loss of possible availability of power that would have to be obtained from other sources not so favourable.

Speaking broadly, any project has the stages of Formulation, Construction, Operation and Maintenance and Decommissioning. Enough exercises are being carried out during the approvals of the projects to ensure that hydro power projects do not adversely affect the environment.

This incidentally, is one of the major reasons for the enormous delay in their approvals. Operation and Maintenance of hydro power projects have hardly been blamed for any adverse effects on the environment. Hydro power projects in the Country have yet not reached the stage of decommissioning as in the United States. It is the Construction of these projects which is labelled with a question mark. It is thus relevant to discuss the prevailing construction methodologies and the possible choices.

Typically, any hydro project comprises a barrier across the river--a barrage/dam; Intake work; a water conductor system--open channel, tunnel or combination of these and a power station--on surface or sub-surface with allied facilities.

The construction of these facilities requires construction of new access roads or at least improvement of the existing roads. As these projects are usually far away from towns, residential and non-residential buildings, mostly of temporary nature, must also be constructed.

#### EXCAVATION

Soon after the approval for a project is received with all the

## 1950

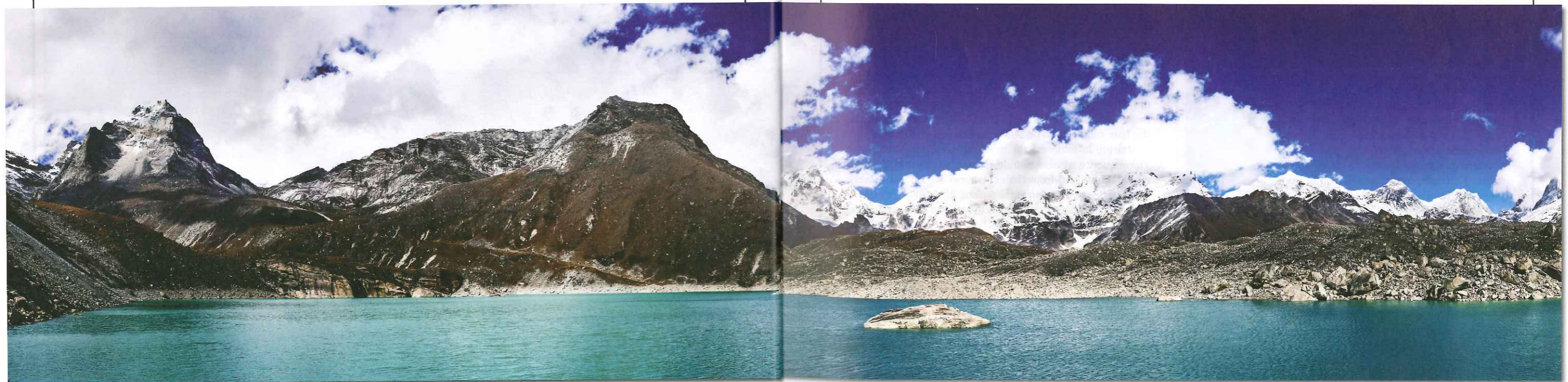
An earthquake cause immense damage to the Brahmaputra Valley.

## 1970

A huge slip in the Alaknanda Valley caused heavy silt content in the discharge of the Ganga River.

statutory clearances, construction of new access roads and the improvements to the existing roads, if required, is commenced basically involving excavation. After the lay out of the project components in the field, the first activity on the project is of excavation, may it be for the construction of the buildings or for the permanent works like the diversion structure, water conductor, power house, etc. Portals have to be established for adits, which also require open excavation. Thus excavation is the initial activity at site. It also results in an immediate change in the topography. Thus the excavation has to be planned and implemented with great caution, which is generally wanting.

1. Excavation for facilities and quarrying for construction material are very important activities having a major bearing on the environment. As mentioned above, open excavation is carried out for roads, dam/barrage, power channel, surface power house, appurtenant works and buildings. Sub surface excavation is carried out for intake works and tunnels. In projects where there is no space to locate the power house in the open or due to other considerations, sub surface excavation is carried out for the cavern to locate power house and appurtenant works. These activities as also the resultant disposal of muck are not given the desired consideration.
2. As a rule, presently the drill and blast



method is adopted for hard and soft rocks. For surface and underground excavation, drilling rigs capable of high speed drilling longer holes for larger pulls are being increasingly deployed. Mostly, excessive charge is being used without any suitable design of the blasting pattern. Even if the blasting pattern is established after a few trials, it is seldom changed with the ever changing nature of rock in the Himalayas. This results in avoidable damage to the stability of slopes in open excavation and shock in the adjustment of stresses in rock mass around the excavated tunnels and caverns. The primary support system, after a pull for the excavation of tunnels, is delayed and stand-up time of the rock is usually exceeded. This results in immense redistribution of stresses in the adjoining rock mass which disturbs the stability of the entire rock mass. In the weak rock zones, there is enormous delay in the provision of final support system. The drill and blast technique has limitations under which the delay can at best be only minimised and not eliminated. In open excavation for roads or other facilities, blasting results in triggering of slope failures. The slope stabilisation is either avoided or delayed till such time it becomes unavoidable. It is felt that the drill and blast technique used in excavation should be stopped or taken up as an exception rather than as a rule. Alternative means of excavation such as road headers, should be used, and TBMs should be deployed in tunnel boring.

- Excavation by rock hammers or road headers in the open may appear to result in slow progress but overall they are expected to provide timely completion of the job. There would be minimum slope failures. Thus there would be savings in time, which is lost in slope stabilisation. The over breaks would be minimal, so the problem of disposal of muck shall be reduced. In open excavation, blasting procedure requires that more land is acquired than actually needed to ensure that no damage takes place in the land not acquired. Several trees even outside the excavation area get damaged during blasting. Thus use of hammers and road headers will result in minimum interference with the environment.
- TBM provide a smooth excavation of the tunnel section. The rock can be provided with the final support immediately behind the boring so

## 1,500

Metre-long drives at minimum were undertaken by double shield TBM at a 30 degree angle on the horizontal.

## 3

Events prior to hydropower development show the severity of natural disasters.

there is less disturbance to the rock mass. A TBM with a double shield is capable of handling very poor rock with no chance of the TBM getting stuck at the face. Himalayan geology does give surprises and such a TBM can bore through varying strata without hindrances. On one particular project, twin inclined bores at 30 degrees to the horizontal of length in excess of 1,500m each for the pressure shafts were bored timely without any hindrances with a double shield TBM. On the same project the open excavation for the power house, done by drill blast method, was hindered quite a lot due to repeated slope failures. Again with a TBM, the excavated muck is the bare minimum and so the problem of its disposal is also minimised.

- Excavation at quarries for the production of coarse and fine aggregate for use in the works has to be very carefully planned. The identification of a suitable quarry, expected yield from the quarry, the working face(s), etc., all have to be very professionally planned. Construction companies very rarely deploy professionals with a mining background for this work. These matters are not given the due considerations. The consequences of bad judgement are enormous in the form of stripping avoidable foliage, felling of additional trees and the excess generation of muck.

### MUCK DISPOSAL

The muck generated in the construction of a project has to be suitably disposed. The basic principle to be kept in mind is that the area where the muck is disposed does not undergo a radical change in the existing land use pattern.

If it is a low lying area and serving as drainage, the drainage should not be blocked. If there is vegetation on the land, good soil should preferably be dumped there. If it is a land obtained on a lease, care should be taken that it is developed for future use.

- The construction companies, large or small, pay only a little attention towards the disposal of muck. It is prevalent to dispose of the muck along the slopes of the river banks or even in the river bed. Such disposal of muck causes siltation in the river bed and is totally prohibited. Yet, this is done with impunity. This action by the construction company is, in my opinion, the single most irritant to the Project Affected People (PAP). Then it is no surprise that certain projects do not meet the concurrence of the PAP just because the earlier projects were constructed in this manner in complete disregard of the health of their river.
- The rock that is either in excess of the requirement of the project or of quality that cannot be used in the works has to be suitably disposed. The first step is to ensure that muck is the bare minimum. The above mentioned suggestions shall contribute to minimise the muck generation.
- The sequence of work should be so planned that the usable material obtained from the excavation is used in the works and resort to quarrying is minimised. Even at the cost of double handling, the usable excavated material should be consumed on the works.
- Proper identification of disposal areas and their capacities should be carried out. Currently, this aspect is not being given due attention and decisions are taken when the excavation has already commenced. No excavation should be allowed to commence until its disposal area has been identified. There is always an acute shortage of suitable disposal areas. It is worth mentioning that for the disposal of silt taken out of the drains in Mumbai, the Corporation has incorporated a condition in the contracts that the contractor shall have to find the site of disposal himself. It

"The current damages in Alaknanda, Mandakini and Bhagirathi Valleys have been triggered by excessive rainfall in a short period in the river basins upstream of the hydroprojects. They may be categorised as 'acts of God' or 'natural disasters.'"

can only be imagined as to what shall be the fate of the environment and the disposed muck that can be washed back into the drains during this very monsoon.

- The designated disposal areas should be such that the disposal of muck shall not foul with the environment. It should be in low lying areas/valleys. The disposal should be carried out in a manner that the existing profile is retained with only an increase in elevation. The disposal should not interfere with the natural drainage. The practice of the dumpers unloading the muck directly in the disposal area and dozing it off should be stopped. The muck should be placed in a graded manner. Large boulders should go down and the voids blinded by spalls and soft rock/soil. Thereafter the muck should be rolled. This shall promote stabilisation of the muck and chances of its flowing down shall be minimised. This will encourage growth of vegetation and help in stability. The toe should have proper retaining wall with check walls in between the disposal area to avoid large scale slippage during rains. This should be done even if it requires handling of muck more than once.

### COST IMPLICATIONS

- Implementation of the above suggestions shall definitely increase the cost of the projects. With the norms being currently adopted in this sector, all the projects would lose the viability criterion. We shall have to change the way we assess the viability of these projects. The criterion should be based on the benefits that shall be reaped in areas where currently there is no power supply or if available is interrupted or lacks in quality (voltage/ power factor). Both tangible and intangible benefits including secondary and tertiary benefits should be included. The advantage of not requiring fossil fuel to be imported to that extent and the carbon credits being available should be included. These benefits compared with the cost should be the criterion.
- As these projects are located in far flung areas, most of them need construction of new roads. Even where the roads exist, they may need major improvements. These roads are used by the public as well during construction of the projects and always thereafter. These roads facilitate development of tourism. It is not appropriate to charge the project for the cost of the roads. The cost of the access roads which are available for public use should be excluded from the cost of the project.
- The change in excavation methodology would need rock breakers, road headers, tunnel boring machines and other allied equipment. Most of these shall have to be imported and would increase the cost of the projects. It may be recalled that there was a time when jack hammers were used for drilling in the drill blast method. However, in view of the performance efficiency of hydraulic drilling rigs, more

and more projects have started using these. Some of the contracts even insist on the use of these rigs. Even these are imported machines but have become affordable. The same can be thought about the road headers and TBMs, etc. The more they are put to use, the more they are likely to get affordable. Currently, contractors do not want to own such machines for they are not sure of their future use and investment on these shall be blocked. Even the foreign companies that are providing these machines on a rental basis are not sure of their continued use in India and quote very high rates. We can certainly look in the future when, to start with, some of our enterprising companies can, in collaboration with foreign companies, start manufacturing units in India

### CONCLUSIONS

- Construction of hydropower projects in a manner as suggested above is likely to cause minimal interference with the stability of Himalayas. They shall also have minimal harmful effect on the environment.
- The current damages in Alaknanda, Mandakini and Bhagirathi Valleys have been triggered by excessive and unprecedented rainfall in a short period in the river basins upstream of the hydroprojects. They may be categorized as 'acts of God' or 'natural disasters'. As evidenced by the aforementioned events of 1950, 1970, and 1978, such extreme occurrences created havocs of unforeseen severities even without the existence of hydro projects. As such, in the case of current damages the hydro projects, in themselves, could not have contributed to the catastrophe in its entirety. In fact Tehri Hydro Project, which is a storage project, absorbed the excess discharge in the Bhagirathi and helped in saving towns of Rishikesh and Haridwar in the downstream.
- Implementation of these suggestions shall require utmost discipline by the construction agencies during the process of excavation. Independent observers with authority to stop the work in case of violation of set norms should concurrently monitor. Not much purpose is served by imposing fines subsequently as the damage caused cannot be got undone. This shall win confidence and cooperation of the local population. This shall be helpful in the approval and execution of projects in the future

www.tunnelsonline.info

A world of information fully archived and searchable at the click of a mouse



The complete source of project, company, market and deal information for the global construction industry.



Quality Data. Deep Insight. Innovative Delivery

Global coverage giving access to:

- 35,000 mega projects
- \$21 trillion projects value
- 100,500 key industry contacts
- 250 market reports
- 7,500 company profiles
- 16,000 deals
- 115,000 news articles

Across the following sectors:

- Tunnelling
- Infrastructure
- Energy & Utilities
- Industrial
- Institutional
- Residential
- Commercial & Leisure

In Association with

For more information on Construction Intelligence Centre visit [www.construction-ic.com](http://www.construction-ic.com) or email [sales@construction-ic.com](mailto:sales@construction-ic.com)

# TALE OF TWO TUNNELS

Engineers from *Ayesa* take a look at the detailed design for construction of NATM tunnels on the Ovulavaripalle to Venkatachalam railway line in Andhra Pradesh, India

Sergio Sánchez-Rodríguez  
Sergio is a civil engineer and the department head for geotechnical engineering at Ayesa.



Mariano Álvarez-Arce  
Mariano is Ayesa's manager and the director of civil engineering and architecture in India.



Rubén Moreno-Bernal  
Rubén is a geotechnical geologist, based in Ayesa's Madrid office as part of the civil engineering and architecture practice.



Alberto Jaén-Toribio  
Formerly a geotechnical and tunnel design engineer with Ayesa, Alberto currently works for Halcrow, based in London.



**D**ETAILED DESIGN and PMC for construction of road bed including two tunnels from km 17/00 to km 35/00 of the new Ovulavaripalle-Venkatachalam railway line in Andhra Pradesh for South Central Railways" was awarded in 2010. Funding for the project was provided by the Ministry of Railways, through Rail Vikas Nigam Limited (RVNL), an entity created to undertake rail projects on behalf of the Indian government.

The ground engineering and tunnelling department of Ayesa Engineering was placed in charge of tunnel design engineering, and developed much of the associated geological and geotechnical study material for the project.

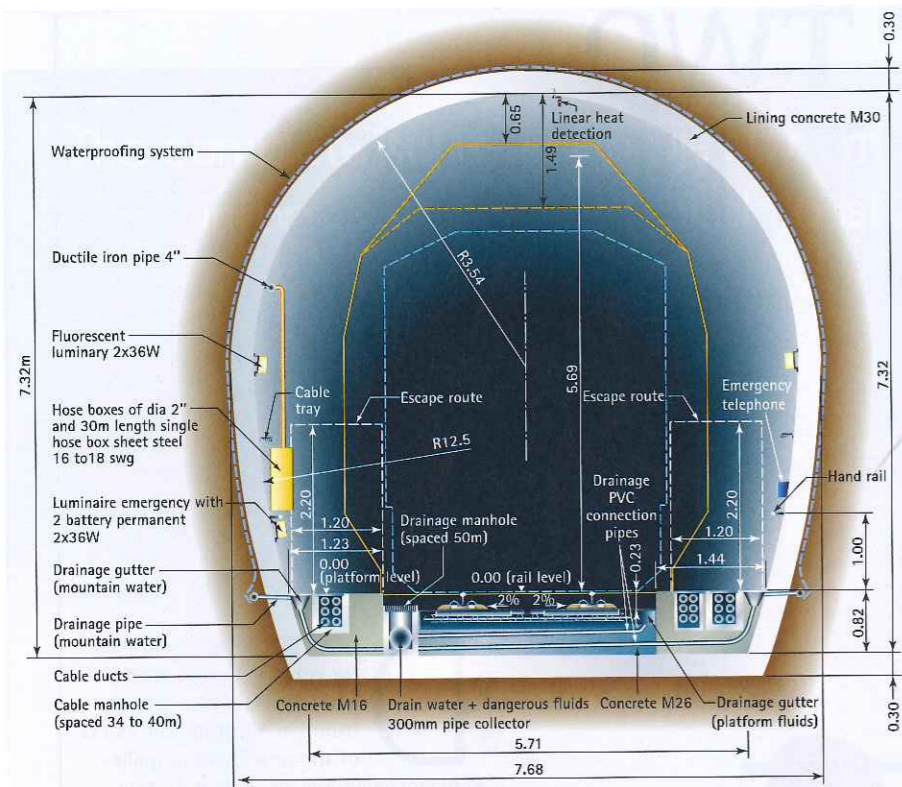
The proposed railway line passes through 18km of deep forests, and includes the construction of two single-track tunnels (named Tunnel T1 and Tunnel T2). The main physical characteristics of these tunnels are listed in Table 1, below.

Due to the high difference existing between the maximum overburdens of these two tunnels, and in spite of the fact that the same geological units were passed through in both cases, the heaviest tunnel supports proposed for Tunnel T1 had to be modified for Tunnel T2 in order to cope with the

Table 1. Characteristics of the proposed rail tunnels

Tunnel	Aerodynamic section (m <sup>2</sup> )	Tunnel length (m)	Maximum overburden (m)	Total length of cut & cover tunnels (m)
T1	38	1,013	80	73
T2		6,671	500	201

Source: Ayesa



"The proposed railway line passes through 18km of deep forests and includes the construction of two single-track tunnels."

available in the area, and it was also impossible to obtain information from stereographic flights.

Consequently, the results obtained were not as good as it had previously been hoped or expected, and consequently design had to be based only on geophysical surveys and geomechanical stations.

Lithologies consist mainly of metamorphic rocks like phyllites and shales (Cumbung Formation), quartzites and shales (Baikonda Formation) and quartzites with conglomerates (Pulivenda Formation) or with shales (Grandikota Formation), all affected by tectonic episodes. Nearly all RMR index values in the area vary within a range from 35 to 75.

Three geotechnical units have been described, based on lithological differences: quartzites (PCq), ferrogenous quartzites and quartzitic phyllites (PCp) and phyllites with shales (PCs). The transition from the bottom lithologies of the strata (PCs) to the quartzites (PCq) at the top occurs in a gradual way.

Phyllites are weaker and have less consistency than quartzitic materials. Therefore, they have been more intensively weathered by previous erosive cycles. Areas marked out by phyllites (PCs) and quartzitic phyllites (PCp) have a more elongated and steep morphology than the marked out ones by the quartzites, which have rounded and almost flat tops.

The geological structure is quite simple, since everything dips between 30 and 50 degrees toward the northeast. Neither faults nor important fracturing zones can be observed.

The main values considered for the parameters of intact rock properties are included in Table 2, above right.

The area is characterised by north-south preferential direction faults at Tunnel T1 and northeast-southwest and northwest-southeast preferential direction at Tunnel T2.

The main problems associated with these faults would be related

Table 2. Rock properties

Unit	Lithology	Tunnel	Unit weight (t/m <sup>3</sup> )	mi	$\sigma_{ci}$ (MPa)	Ei (MPa)
PCq	Quartzite	T1 & T2	2.8	20	80	30000-35000
PCp	Quartzitic phyllite	T1 & T2	2.75	15	65	25000-30000
PCs	Phyllite with shale and gneiss	T1	2.71	10	34	12710
PCs	Phyllite with shale and gneiss	T2	2.74	10	46	28775
PCs'	Highly weathered phyllite with shale and gneiss (IV)	T1 & T2	2.6	10	10	7600
F	Faults	T1 & T2	2.4	10	10	5000

Source: Ayesa

to the presence of clayey milonites or cataclasites presenting poor geomechanical conditions, due to the fact that this could create high flows to the excavation depending on its hydrogeological conditions.

**CONSTRUCTION**

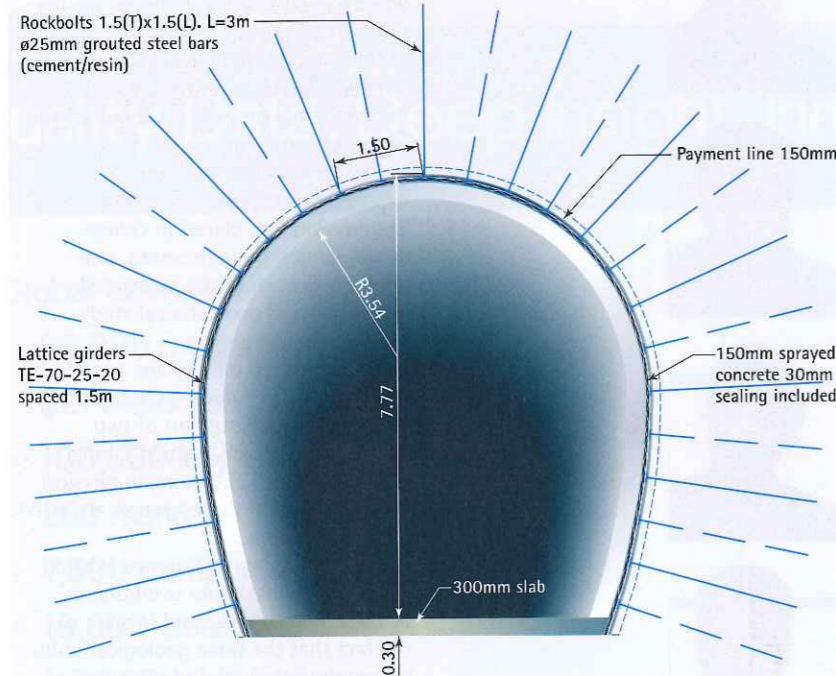
Both tunnels are to be bored with full

face excavation, following the principles of NATM. The possible option of a TBM was dismissed once the possibility of opening an intermediate cut and cover zone for Tunnel T2 was finally considered.

A functional section with an aerodynamic section of 38m<sup>2</sup> was finally considered. It was also necessary to design some special wider functional sections for construction recesses, and for trolley refuges.

Six different types of support sections were considered.

Below: An outcrop of phyllites on the project's site



Above, top: Figure 1, Functional section with slab

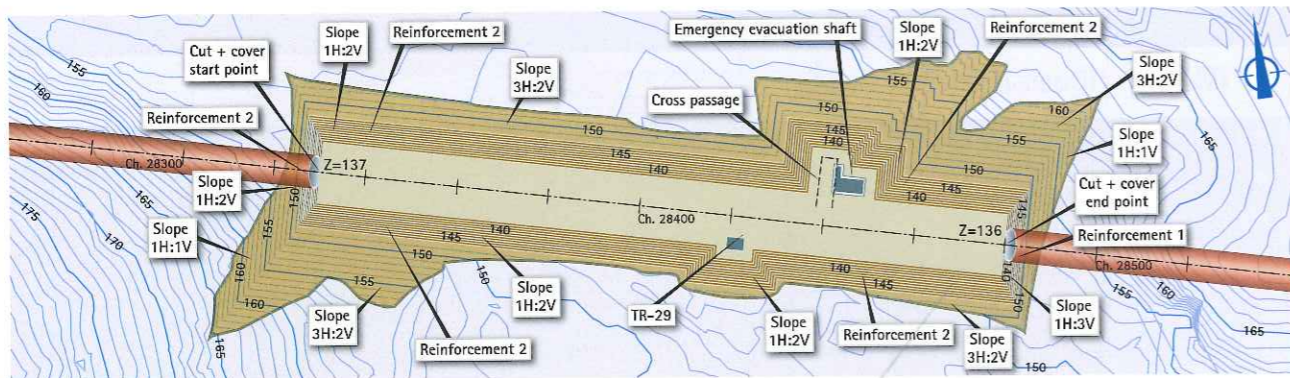
Above, bottom: Figure 2, Support section SCIV

possible appearance of high squeezing risks.

**GEOLOGICAL AND GEOTECHNICAL STUDIES**

The most significant difficulty emerged with the start of the design phase, and was related to the development of the geological mapping and geotechnical investigation campaign, which was necessary to obtain geotechnical and survey reports. Namely, the practical impossibility of transporting drilling equipment further than tunnel portals due to the steep and unforgiving topography.

On the other hand, there was a lack of adequate equipment



**"Geophysical investigations were of great help to designers. Nevertheless some uncertainty remains regarding deeper sections of main tunnel"**

The first three support sections were alike in both tunnels, while the rest had to be adapted due to the high discrepancy existing between the maximum overburden of each tunnel.

The use of an invert arch was recommended when RMR values were lower than 35. Specific support sections were also designed for fault crossings or squeezing zones.

Expansion bolts were proposed for support sections SC-I and SC-II, while corrugated steel bars were chosen for support sections SC-III and SC-IV. Self-drilling bolts umbrellas of 10m length were also proposed for fault crossings.

Excavation method by drilling and blasting was suggested for sections SC-I, SC-II and SC-III.

The rest of support sections could easily be excavated by mechanical means. Lattice girders types 50-25-20 and 50-32-20 were proposed for Tunnel T1 and heavier types 70-25-20 and 95-25-20 for Tunnel T2, due to the presence of higher overburdens. Support sections were checked by numerical modelling using finite differences method with FLAC3D.

Ground improvements proposed are mainly face reinforcements with fibreglass nails, provisional earth slope pillars, drainages on face, sprayed concrete in face and pipe umbrellas when required.

A special support section for squeezing zones was designed for Tunnel T2. Support proposed consisted of self-drilling bolts surrounding the whole excavated section, TH-36

steel ribs, LSC elements (lining stress controllers) and 25cm of shotcrete. This design could finally be modified during construction once that real geotechnical information at highest depths is obtained, due to the lack of information available during design, as it was mentioned earlier.

This section was developed considering that similar lithologies at tunnel depths higher than 250m have developed squeezing problems in Indian tunnels in the last years.

**CUT AND COVER TUNNELS AND EVACUATION SHAFTS**

Since Tunnel T2 is excavated through a low overburden zone, a cut and cover tunnel was proposed in order to create two intermediate attack points for tunnel excavation, consequently reducing total excavation time. An emergency evacuation shaft was also included within this zone.

**CONCLUSIONS**

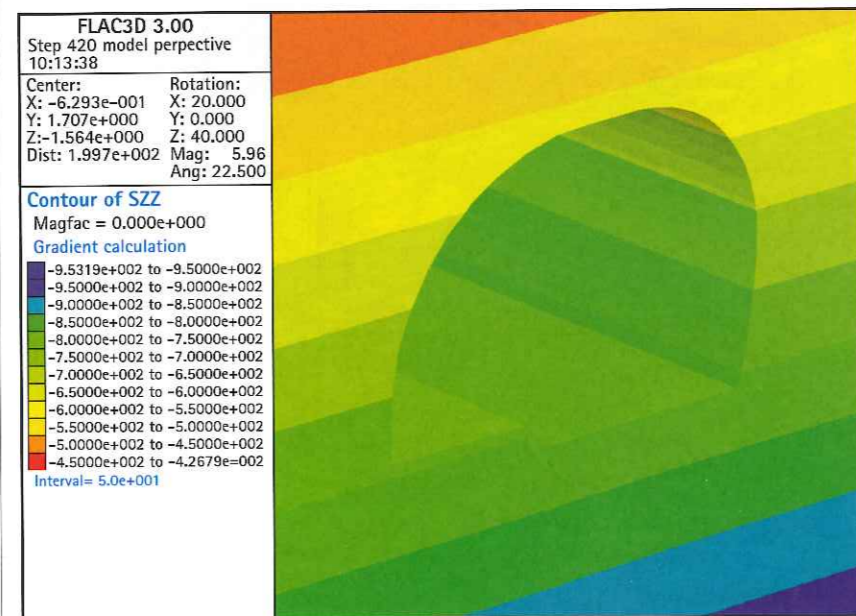
The two tunnel design calls for length of 6,670m and maximum overburden of 500m.

Tunnel designers had to face with difficulties mainly associated with the lack of some basic information like previous geological studies or available aerial photographs (stereo pairs). Also coping with logistics and the difficulty of placing borehole drilling equipment further than tunnel portals due to the steep landscape was a key issue.

Geophysical investigations were of great help to designers, Nevertheless some uncertainty remains regarding deeper sections of main tunnel

Above: Figure 3, Cut and cover zone from above

Below: Figure 4, Support section for construction recesses in FLAC3D



**UNDERGROUND UTILITIES**



**Going further in 2014**

A complete subsurface construction source for the utilities industry

# DELHI'S BELLY

Supplying eight of the 25 TBMs required for Delhi Metro's Phase III, manufacturer Terratec is heavily invested in the project. In a series of vignettes, *Tunnels* checks out how the different worksites are being handled in a city crowded beyond capacity

IT'S A hot day – by European standards – in Delhi in late October. The driver has just leant on his horn as another Hero Honda motorcycle scythes across six lanes of traffic on a four-lane arterial road. The sound is lost in the orchestra of honking all around us, as the drivers use a kind of group sonar to keep track of other vehicles.

"It's gotten a lot worse," says Bill Brundan, site operations manager for TBM manufacturer Terratec.

"Since I was last working here, about half a decade ago, I think the traffic might have doubled."

The imperious struts of a section of Delhi Metro elevated rail divide the traffic flowing in different directions. These enormous concrete pillars are at regular intervals in perfect alignment until they are lost from sight in the haze of pollution.

Everywhere one looks there are signs that Delhi has a serious infrastructure challenge squarely facing it, and that an MRT project on the scale of the Delhi Metro is only just keeping pace is incredible.

The cyan hoardings of the Delhi Metro Rail Corporation (DMRC) are everywhere; the project has an incredible presence in the city as tunnelling begins on its third phase. Some 45km of underground line is needed for Phase III, with 31 underground stations. With the 'easier' routes being constructed largely above ground already, a greater and greater proportion of subsequent phases will be underground. Phase III has almost as much tunnelling as the

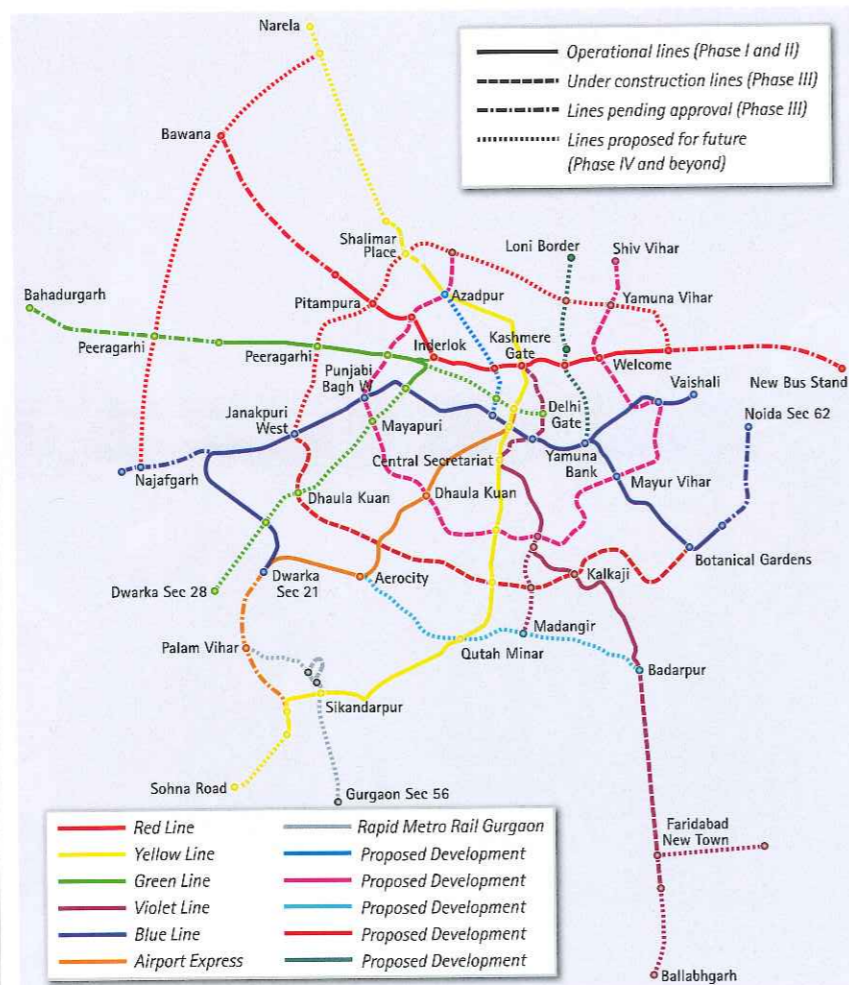


Table 1. Machine and drive attributes

DMRC Contract	CC-07	CC-20	CC-24	CC-34
Contractor:	METROSTROY-ERA JV	J.KUMAR-CRTG JV	J.KUMAR-CRTG JV	HCC-SAMSUNG JV
Number of TBM's:	2	2	2	2
TBM Serial Number:	S23, S24	S26, S27	S25, S28	S36, S37
Design & Manufacture:	TERRATEC	TERRATEC	TERRATEC	TERRATEC
TBM Type:	EPB Shield Machine	EPB Shield Machine	EPB Shield Machine	EPB Shield Machine
Expected geology:	Mixed Soil/Rock	Mixed Soil/Rock	Mixed Soil/Rock	Soil
Shield Diameter:	6,610mm	6,610mm	6,610mm	6,520mm
Segment Ring Dimensions:	ID6350mm/OD5800mm/L1400mm	ID6350mm/OD5800mm/L1400mm	ID6350mm/OD5800mm/L1400mm	ID6350mm/OD5800mm/L1400mm
Number of Segments:	5+Key	5+Key	5+Key	5+Key
<b>Cutterhead</b>				
- Type:	Dome	Dome	Dome	Spoke
- Opening Ratio:	37%	37%	37%	58%
- Drive Method:	VFD - Electric Motors	VFD - Electric Motors	VFD - Electric Motors	VFD - Electric Motors
- Installed Power:	900kW	960kW	900kW	550kW
- Nominal Torque:	5628kNm	5424kNm	5628kNm	5416kNm
- Max. Speed:	3rpm	5rpm	3rpm	2rpm
Max. Advancing Speed:	71mm/minute	71mm/minute	71mm/minute	71mm/minute
Max. Thrust Capacity:	40,000kN @ 350bar	40,000kN @ 350bar	40,000kN @ 350bar	40,000kN @ 350bar
Articulation Type:	Active	Active	Active	Active
Articulation Capacity:	35,000kN	35,000kN	35,000kN	35,000kN
Min Curve Radius:	250m	250m	250m	250m
Back-filling System:	2-Liquid Type	2-Liquid Type	2-Liquid Type	2-Liquid Type
<b>Tunnel Data</b>				
Tunnel Drives:	2 per TBM	2 per TBM	3 per TBM	2 per TBM
Drive Locations:	Jama Masjid to Lal Quila, Kashmir Gate to Lal Quila	Naraina Vihar, Mayapuri and Delhi Cantt.	Hazrat Nizamuddin Station to Ashram Station; Lajpat Nagar Station to Vinoba Puri Station to Ashram Station.	Janakpuri West to Palam, Delhi
Approximate Tunnel Length:	1,980m per TBM	1,290m per TBM	3,332m per TBM	1,795m per TBM
Geology:	Drive 1; Alluvial Sandy Silt/Clay, possibly some Moderately Weathered Rock. Drive 2; Alluvial Sandy Silt/Clay	Drive 1; Weathered Quartzite Rock. Drive 2; Alluvium Deposits. Drive 3; Alluvium Deposits.	Drive 1; Sandy Silt to Gravelly Silt and Sand. Drive 2; Sandy Silt to Silty Sand with Gravel. Drive 3; Highly Fractured & Weathered Quartzite	Mixed Soil, Soft Clay, Stiff Clay, Dense Clay & Silty Sand, Dense Sand

Source: Terratec

previous two combined.

For this project, a fleet of 25 TBMs is required, of which eight are manufactured by Terratec.

### CC07

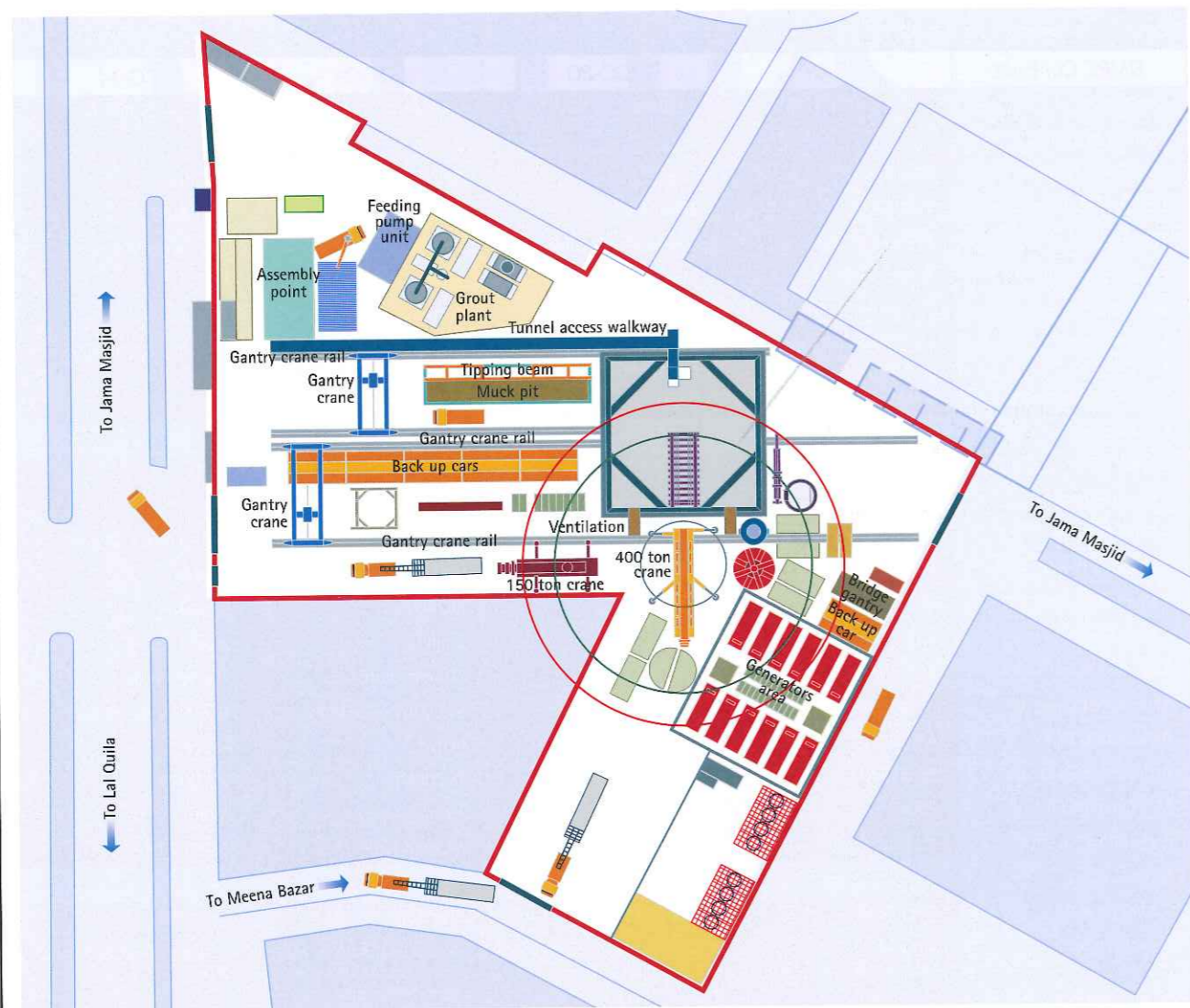
Contract CC07 is located in the heart of Delhi, running approximately along the west side the Red Fort, and spans three sites (from north to south): Kashmere Gate, Lal Quila and Jama Masjid. The contractor is a JV of Metrostroy-ERA. The Jama Masjid launch site on CC07 has a mixed demographic of staff. Metrostroy-ERA has retained responsibility for the project management and all the working labour, whilst the specialised team to carry out the operation and maintenance of the TBM has been brought from Terratec's field service personnel.

Predominantly from Thailand, they tell *Tunnels* that they have a particularly strong teamwork culture, and find it most

Opposite: Figure 1, Delhi's Metro with Phase III and future expansion

important to stay together as a unit, from job to job. The workers are housed together in Delhi, and have brought their own cook with them. The result is an exceptionally quiet bustle on site, with an arcane system of gestures, hand and eye signals, with very few shouts. Everyone knows where to look, and who is watching what. There is more noise from the flies.

Brundan added, "We believe that supplying services is very important in markets such as India, Thailand and the Middle East and we are very active in helping to assemble, operate and service our TBMs if that is required by the



contractors. In Delhi we are proving 24-7 operation and maintenance services, with teams from four to 18 people per TBM, depending on the Client's needs. CC-07 is challenging because of its location and also because of the constraints of the actual site."

**Left hanging**

The former managing director of DMRC, Elattuvalapil Sreedharan, is largely credited for the past successes of the Delhi Metro scheme as a whole.

Work on Indian projects is often described as 'organised chaos' by expats, with the greatest contractors excellent at 'fighting fires'.

Jama Masjid is working well – the client actually commented that the field service team had executed the best (well grouted, little ingress) initial drive on Phase III – but it is not without challenging logistics. While *Tunnels* is on site, there are problems with a gantry crane contractor that has delivered its crane, but not showed up to assemble

*Above: Figure 2, Worksite layout during TBM assembly, with routes in and out of the site*

it. In the end, to speed up progress, the Terratec personnel assemble the frame, but are not certified to handle the electrics to make it operational, which still waited upon the vendor.

**CC-24**

Executed by a JV of local contractor J. Kumar & Associates, and CRTG, the CC-24 contract covers the sites and associated tunnels for Hazarat Station, Ashram Station, Lajpat Nagar Station and Vinoba Puri Station.

The Delhi Metro lined tunnels are OD 6,350mm, id 5,800mm with a cutting diameter of 6,650mm. The tightest curve on CC-24 is 320m, and grade lies in the range of 1-3 per cent. Geology is competent and no challenges from the scope of excavation work demanded are foreseen.

This is a first use for the Delhi Metro, and for all tunnel projects in India, of real-time monitoring. A system by Encardio-Rite Electronics of India is in use by an independent consultant to conduct the investigation works.

It's not unusual for the Delhi Metro to lead the way in Indian tunnelling in other regards. For instance, the health and safety standards are famously high on projects handled by DMRC, with swathes of work shut down on previous occasions when questions over worker safety emerged. It can be difficult to enforce at times, though.

There's no such problem on CC-24, with the contractor entirely on top of safety standards and with its own team.

All conditional risk is on the contractor – DMRC lays nearly all risk on the contractor as standard – with some progress rate risk on the machinery manufacturer.

Speaking to *Tunnels* in January 2013, Bob Moncrieff of Rona Consulting said, "In India it is usual for all financial and geotechnical risk to be placed on the contractor and away from the client. They are very one-sided contracts. The industry is getting better at site investigation though, but with a short tender time, it is a brave contractor that undertakes extra investigation. I suspect if this does not change quickly, a contractor will eventually 'catch a cold' in unexpectedly bad conditions, and this will force prices up from then onwards. The current contract culture is short sighted."

**CC-20**

The two sites forming this contract are Naraina Station and Delhi Cantonment, to the west of central Delhi – a military headquarters district. The area is less confined than many of the other sites in Delhi, but logistics are still a challenge. The contractor is the same as for CC-24, J. Kumar/CRTG.

The JV's work on CC-20 was delayed by land acquisition processes as *Tunnels* visited. An island of shops and residences in the middle of the Naraina worksite had yet to be cleared, but preparation works were advanced; with pile rebar stacked and ready, and ground leveling underway. Naraina Station's

**"They are very one-side contracts...But with a short tender time, it is a brave contractor that undertakes extra investigation"**

*Below: Some contracts are advancing quicker than others due to land acquisition delays*



diaphragm wall was down despite the island of local residents.

To offset some of the impact of the delays, and following DMRC permission, the two CC-20 TBMs will be transferred to CC-24 to complete two drives, the works of which are more advanced. The J. Kumar-CRTG JV is on both jobs, making this possible.

Brundan gave an update as *Tunnels* went to press, "The CC-20 machines will go to CC-24 for one drive each between Lajpat Nagar Station to Vinob Puri Station. This is now confirmed, and the assembly is planned to commence middle of February. The CC-20 project has also moved forward and the land problems are resolved now with all the shafts progressing. As soon as the CC-20 machines complete their CC-24 drives, they will be moved back to CC-20 to start their original drives.

"All four machines are similar and all can manage the soil or rock conditions without any concern. At CC-20 though one of the drives is expected to be mostly rock, The CC-20 machines have slightly more power and more speed suitable for rock conditions, and you also use less torque in rock than in soft ground."

Works packages are relatively small on Delhi Metro, but this is an advantage of keeping similar works 'in the family'. The sites are streamlined in this way, and now managed together.

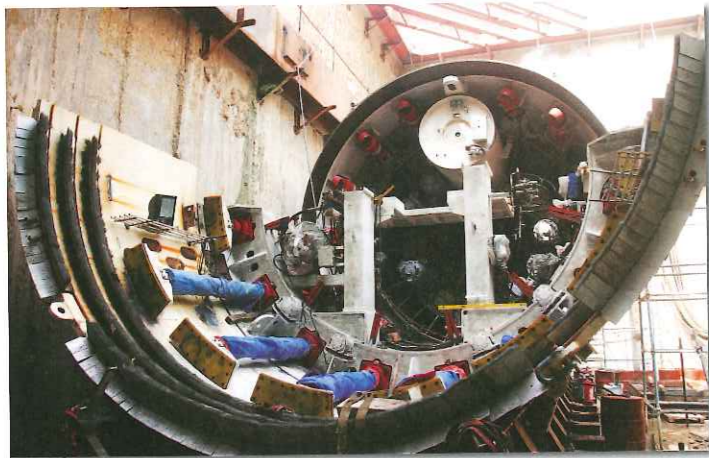
A sophisticated site office was also already set up, with offices for various engineering disciplines.

"It's the general experience with J. Kumar, they are very eager to learn and do things properly," says Brundan.

"It's their first tunnelling job, and our first time working with them. Tunnelling is very difficult to handle, and highly specialised. J. Kumar's executive director Nalin Gupta holds meetings from 6pm until midnight, eager to hammer out every last detail.

"It's personally tiring, but professionally very encouraging. This company is great to work with."

It is common in India for a great deal of help to be given to local contractors. CRTG provides the joint venture with the necessary experience in tunnelling by its engineers at site, but manufacturer



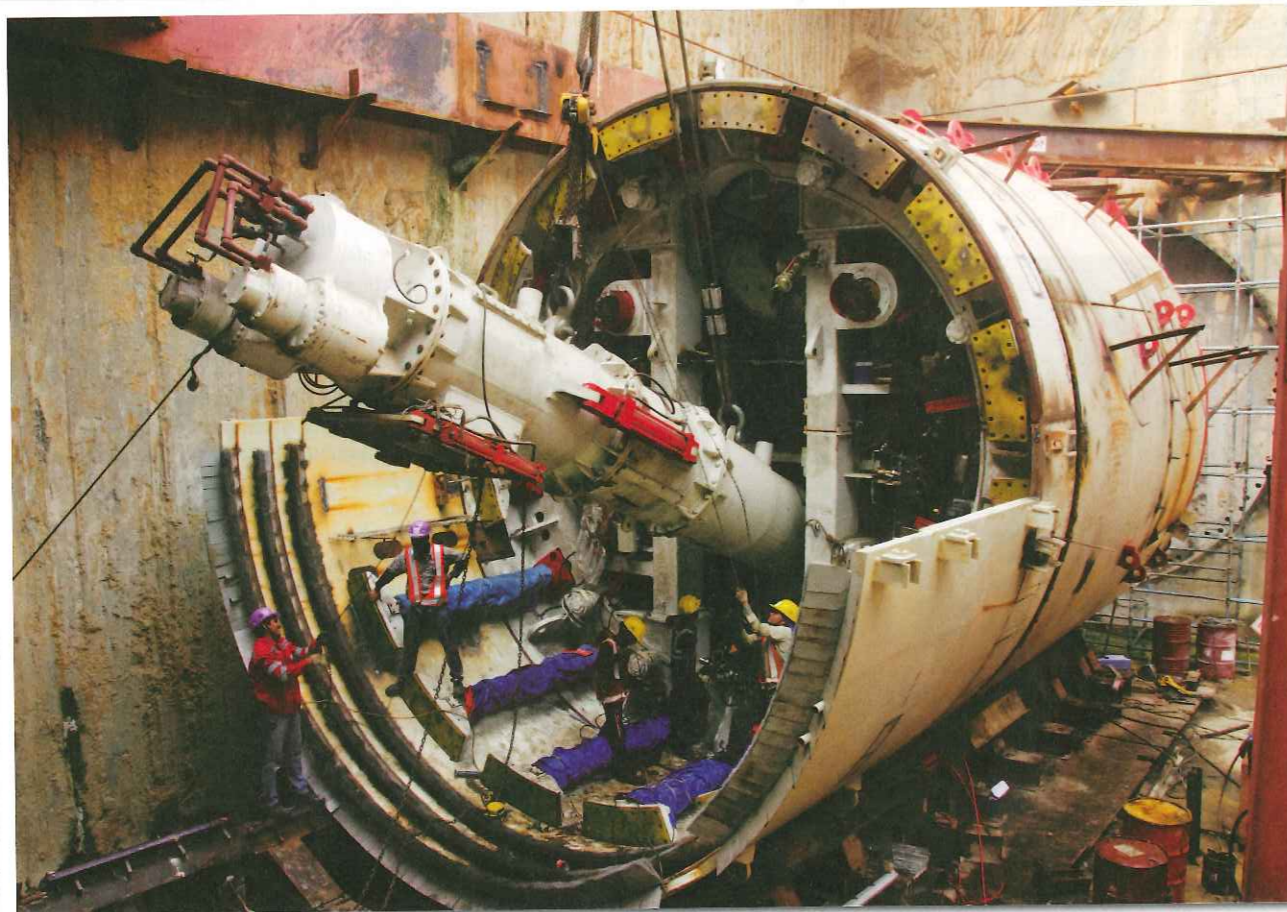
of the TBMs will come as close as 4.5m away while travelling between the piles. There will be stringent monitoring, and grouting if needed, but at this time it is thought no additional measures will be taken.

Other obstacles involve a flyover with piles, and the existing Dabri Mor Station, which means a passenger walkway cannot be excavated by open cut.

**Making lemons**

The segment factory for CC-20/24 is also doubling for J.Kumar's shield storage. The CC-20 launch site was not ready to receive the Terratec TBM's when delivered to site.

Fortunately there proved to be more than adequate space on the segment site for storage, but this presented the challenge of protective maintenance on the machine, including oiling and greasing and dust protection, but also this runs



All: TBM assembly at the shaft bottom in Delhi

support is also key during the TBM erection, commissioning and tunnel construction.

Engineers on site hoped that the legal wrangling with site acquisitions would be concluded within the month.

**CC-34**

Project CC-34 was awarded to a JV of HCC-Samsung. Covering the sites of Janakpuri West Station, Palam Station, and the cut and cover Dabri Mor and Dashrath Puri stations between. A key future challenge on this project will be navigating the piles of the existing Janakpuri West Station. On its drive, one



The centre of the Red Fort in Delhi



**Segment yard**

In the Mundka industrial area towards the western extremity of Delhi, DMRC leases an area of land to its various companies for segment factories to be set up. The works packages are divided between a number of contractors, so there are multiple factories in the vicinity. Segment factory manager from J. Kumar-CRTG JV, Nath Poopong, shows Tunnels around his setup for contracts CC-20 and CC-24.

The contractor bought the yard from ITD, which was working on the earlier Phase II of the metro. If the setup is no longer required, the contractor will likely sell it on to groups set to work on subsequent metro phases.

Of around half a dozen factories on site, it is the only one that has a connection to the national grid, which was down to the preference of the previous occupiers. Still vulnerable to Delhi's power cuts, there is also generator power available. All TBMs on the sites visited are generator-powered.

Korea Mold supplied the moulds for CC-24, Poopong worked with their products previously in Dubai as a project manager for Obayashi. Concrete is mixed with a micro silica additive for permeability, and reinforced with cage rebar. No poly or steel fibres are called for by the specification.

The heat of summer requires a cooling water system, with temperatures easily rising into the 40°C. While Delhi's brief and relatively mild winter sees factory reliance on steam curing with a temperature of 55°C. Still, demoulding time is lengthened from the summer duration of 4/5 hours at 12.5kN strength. Buildings in the city are not typically well sealed against the cold, making this period of the year more miserable than might be expected.

The segments are a five plus key universal ring, with glued VIP gaskets from the UK. There are three types being produced to form rings in soft ground, rock and sand. The only real difference between the three is the amount of rebar.

the risk of circumstantial damage from operations such as truck movements. Cosmetic marks from the storage near a dirt track were visible on the shield, but nothing more.

**FUTURE**

On the state of contracts in Delhi, and future work in the country, Brundan concludes, "The current Delhi Metro work on Phase III has all now been awarded. Future phases will come up in the next few years and of course we would be very interested in being a part of this huge and impressive set of projects."

On the sites in question, tunnelling for all sections was expected to be complete by the end of 2014. CC07 and 24 are proceeding to this schedule. CC-20 has had land acquisition issues and delay of approximately 6 months, allowing J.Kumar -CRTG's use of the CC-20 machines on CC24. Accelerating CC-24. CC-20 is now back on track with TBM work expected to start in the summer. CC-34 is approximately two months behind, but tunnelling is still expected to be complete in 2014



# NASTT'S 2014 NO-DIG SHOW

APRIL 13-17, 2014 - GAYLORD PALMS - ORLANDO, FLORIDA



# THE MAGIC OF TRENCHLESS

- TECHNICAL PAPERS
- INDUSTRY EXHIBITS
- SPECIALIZED SEMINARS
- NETWORKING EVENTS
- SPECIAL AWARDS
- INNOVATIONS
- ENTERTAINMENT



[WWW.NODIGSHOW.COM](http://WWW.NODIGSHOW.COM)

### PLATINUM SPONSORS



### GOLD SPONSORS



### SILVER SPONSORS



Although less developed markets throughout the world have lower standards for machinery, a genesis of mechanised tunnelling has already begun, with a data revelation to follow. Rhian Owen reports



*Rhian Owen*

As a journalist and technical writer Rhian began working with *Tunnels* in 2011

**D**RILL AND blast is a time-tested method of excavation. The basic principle of cutting a hole, filling it with explosive, plugging and detonating, has remained steadfast as the equipment, the materials and the projects have become ever more sophisticated and ambitious. None more so than the drill rig. A replacement for the hammer and rod that was used to cut holes into rock faces in the early years of deep mining, the drill rig is now a complex, intelligent and agile machine that can manipulate the excavation cycle, reacting quickly to the changing environment to speed advance rates, minimise draws and ultimately reduce cost



# BIG BANG THEORY



The agility of the drill rig is pitched against the brute strength of the hard rock TBM in the intensifying battle of methods. However, the low cost of equipment and the manufacturers' unrelenting drive for improvement is helping drill and blast hold its position as the dominant technique for hard rock tunnelling.

Drill and blast, often referred to as conventional tunnelling, is able to deal with complex shapes and much closer proximities to building than alternative methods, "The tunnel does not need to be round," says Wilhelm Papst of Sandvik's mechanical cutting division. "There are many underground possibilities. Highway, railway and metro tunnels at the traditional end of the market, and less conventional are storage facilities, shopping centres, even ice hockey arenas, of all kinds of shapes." Papst explains that five years ago the technology was not able to handle these complex jobs, but developments in both explosives and data and computing systems have transformed the playing field.

This flexibility and its lower power consumption helps keep a steady demand for the method, "it requires less energy to blast rock than it does to cut it," says Papst.

The continuing research and development of drill rigs has focused on improving a few key factors: increasing the speed and reliability of hydraulic drills for increased productivity and penetration; improving accuracy through rig structural changes such as more rigid booms; improving accuracy through electronic guidance and drill-pattern systems, leading to less overbreak; and developing instrumentation for the

**"This flexibility and its low power consumption helps keep a steady demand for the drill and blast method"**



Above: Drill rigs working in concert, allowing for faster advance over a greater excavation area

drilling process, which can be used for more automatic control, and input to blast design.

#### AUTOMATION

For this conventional tunnelling method to develop and secure the most complex tunnelling projects the equipment needed to become less reliant on the operator.

The blast patterns required to maximise the draw from a single blast and minimise the impact on existing infrastructure has called for laser guided drilling methods, accurate data gathering and sophisticated software to make sense of it all.

"The level of automation has improved significantly," says Papst.

iSure (Intelligent Sandvik Underground Rock Excavation) software is a new tool for managing tunnel or underground excavation projects. With it, the drilling and blasting design takes place in the blast plane.

This way, parameterisation of the drill holes, and burden calculation can be used for optimising the locations of the holes. The explosives used in different parts of the pattern are



also specified as the degree of charge and the relative strength of the explosive are used for calculation purposes during the design process.

Based on this information, the total consumption of the explosives per round, and for example charge detonating at specific time (per specific delay), can be illustrated.

Another of the features being introduced with modern drill rig software is the ability to include detonators and group or surface delay detonators in the design process.

The software enables real time monitoring of momentary situation as the design advances. If selected, information is available on the real delay times with or without the extra surface delay; the number of detonators initiating at the specified delay time, and the amount of explosives initiating simultaneously.

As the excavation advances, the designer can revise the vibration measurement results and go back to the drilling and blasting pattern design to trace the cause of increased vibrations and make modifications as required.

In addition to the real time momentary illustration, the design process is made easier for the user by blast simulation. Simultaneous detonators on a specified delay time can be highlighted, while the already initiated delays are displayed faintly.

#### THE SPICE OF LIFE

The customising of the drill rig to suit the job will bring the best results in performance and project delivery. The comparatively low cost of drill rigs means the project will usually have greater freedom to order a bespoke jumbo.

"Put simply, for each of the different models there are a lot of packages and options tailored for the job. There is a range of computerised jumbos, particularly designed for tunnel construction. Then there is a range of jumbos that are not computerised, a more conventional setup - and there's a bigger number of these."

"We have a range of jumbos starting from one boom jumbos, which are particularly used in mining and small

**2** Typical round length, in metres, in poor rock conditions. Round length is shortened as conditions deteriorate

tunnels, to two or even three booms with coverage of more than 200sqm. Our DT line is targeted at the drilling industry and our DD line is aimed at miners."

Across all lines the development driver has been increasing drilling accuracy, "mainly due to the cost of excavating the tunnel," says Papst. "There's always a minimum shape of the tunnel that is defined by the client, over excavation will drive up the cost of tunnelling. In many cases, a tunnel needs to be concrete lined.

So if you're not accurate, and you over excavate there will be costs associated with filling that over excavated space with concrete, which is expensive. It's a double whammy if you don't do it correctly."

Above: View of the face from rig operator's cabin

Below: Drilling pattern software graphic display



Large cost savings are possible by achieving a smooth profile by drill and blast, chiefly through rig data controls.

An example project called for a 770m-long rock cavern top heading with planned sectional dimension of 10m x 20m (approximately 153m<sup>2</sup>), thus requiring an excavation of 118,000m<sup>3</sup> of solids. With minor additional drilling costs, some EUR 720,000 (USD 10.5M) in savings were achieved in the extra concrete that would have been used to fill overbreaks.

Savings were also made from reduced sprayed concrete use amounting to EUR 103,000 (USD 150k), and also in mucking out and explosives, further totaling around EUR 973k (USD 1.41M). The work was also completed nearly a month earlier than otherwise.

While rigs without the sophisticated computer systems still lead the market, the trend is towards great automation. Europe has lead the way and computerised jumbos are prevalent on drill and blast job site. But developing countries are considerably behind and

"Large cost savings are possible by achieving a smooth profile by drill and blast chiefly through rig data controls"



Table 1. Average advance rates

Conditions	Average advance rate (m/month)	
	Single heading	Multiple headings
Easy - Competent rock - Minimal rock support (some rock bolts)	200-300	300-450
Average - Variable rock conditions - Regular support (rock bolts, some sprayed concrete)	150-250	200-350
Difficult - Soft/fractured rock - Heavy rock support necessary (rock bolts, sprayed concrete, steel mesh, steel arches)	< 150	100-200

Note: Average advance rates for single- or multiple-face operation of blasthole drilling, based on 3-shift continuous operation

may be some way from using the latest technology: "The sale of computerised jumbos will increase," says Papst, "But a lot of tunnels are still done with hand held drills - in many developing countries mechanised drilling is not used yet. Therefore, mechanised jumbos with fewer features will replace hand held operations initially.

Afterwards, moving into the future, more technologically advanced solutions will be introduced." The temptation to produce lower quality drill rigs for the developing market has been avoided.

Papst explains, "Even though it might seem that the market cannot justify all the safety features from a business point of view, we cannot sacrifice the safety of the operators by trying to cut corners."

He says that when designing the equipment "safety is our philosophy, we need to meet the strictest standards. It might sound unnecessary for the global market to apply a standard enforced in just one country or even just one state, but in the end, safety must take the lead."

Papst adds, "We often have the same contractors operating all over the world, and they want to have the same equipment wherever they are operating."

WHEN TO DRILL AND BLAST

Drill and blast can be applied to a wide range of dimensions, depending on the size of the drilling equipment chosen. A limit for mechanised drilling at the lower end is determined by safety considerations when working around machinery for drilling and loading out in a narrow space. Thus the smallest possible mechanised drill-and-blast tunnel is about 2.5m by 2.5m (although maybe non-mechanised drilling could be used).

The largest section that can be covered by a drill rig from a single lateral position is about 200m<sup>2</sup>, although rigs could be used in parallel or in sequential excavation.

Whether a large number of booms (up to four are available on mobile rigs) is desirable is a subject of much debate between contractors, whether in general or related to specific project conditions.

Clearly an efficient computerised operational system can make the best use of the maximum number of drills, but some contractors question whether a fourth produces much advantage in most tunnelling. Some would even prefer two, two-boom rigs.

Rock condition is an important consideration in deciding

whether or not to use drill and blast since movement on joint planes, voids, and even changes in rock hardness can seriously affect drilling and blasting efficiency.

Modern drilling control systems can be set up to automatically adjust for some unusual boring progress to avoid stuck bits and broken drill steel, pulling back slightly when difficulties are encountered.

Although still at early stages of introduction, measurement-while-drilling (MWD) results can provide data to determine the most appropriate hole charging.

Another way of coping with poor ground in drill and blast is to reduce the drill round length. In good rock conditions the maximum is about 6m



as the longest drill steel are 21ft (6.44m) long. Round lengths are progressively reduced for poorer rock from 5.1-4.6m in good rock, 4 to 2m in fair rock and 2m or less in poor rock.

Round shortening is mainly a matter of reducing the length of initially exposed ground, if the rock is poor, to maintain natural support.

However it follows that the shorter the hole drilled, the less likelihood there is of drilling problems in one hole due to ground instability.

Shorter rounds tend to increase cycle times and therefore tunnelling progress. This is also affected by extra time for additional ground support unless, perhaps, it is possible for one drill rig to work on more than one face, depending on the tunnel project layout.

This may not be so much of a problem with a TBM unless the ground is blocky.

The effects of ground conditions on drill and blast average advance rates in various rock conditions are seen in Table 1, above

To advertise here call Tom Willard on +44 (0) 203 096 2608 or email [twillard@tunnelsonline.info](mailto:twillard@tunnelsonline.info)



This is not the full list of British Tunnelling Society Corporate Members. To see a full list of all members visit: [www.britishtunnelling.org.uk](http://www.britishtunnelling.org.uk)

**Anderson Acoustics**  
www.andersonacoustics.co.uk

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

**ATKINS**  
www.atkinsglobal.com

**BASF**  
The Chemical Company  
www.ugc.basf.com

**Cooper & Turner**  
Manufacturers and suppliers of connection and embedded items for segment lined tunnels worldwide  
www.cooperandturner.co.uk

**COSTAIN**  
Stephen Meadowcroft  
T: +44 (0)162 884 2444  
E: stephen.meadowcroft@costain.com  
www.costain.com

**DANNY SULLIVAN GROUP**  
enquiries@dannysullivan.co.uk  
+44 (0)20 8961 1900  
www.dannysullivan.co.uk

**DONALDSON ASSOCIATES**  
www.donaldsonassociates.com

**www.dr-sauer.com**  
london@dr-sauer.com

**THE GALLDRISS GROUP**  
enquiries@galldris.co.uk  
01992 763000  
www.galldris.co.uk

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

**GRACE de neef**  
Leader in injection and waterproofing products  
www.deneef.com

**HALFEN**  
YOUR BEST CONNECTIONS  
01582 470300  
WWW.HALFEN.CO.UK

**HERRENKNECHT**  
Tunnelling Systems  
www.herrenknecht.com

**Hunter Personnel**  
Recruiting For Your Industry  
Specialists in Tunnelling and Infrastructure Recruitment  
www.hunterpersonnel.com

**itmsoil**  
t: +44 (0) 1825 765044 e: info@itmsoil.com  
f: +44 (0) 1825 744398 w: www.itmsoil.com



This is not the full list of British Tunnelling Society Corporate Members. To see a full list of all members visit: [www.britishtunnelling.org.uk](http://www.britishtunnelling.org.uk)



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

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

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

**McGINLEY SUPPORT SERVICES**  
01923 696 600  
07974 789 715  
www.mcginley.co.uk

**MORGAN SINDALL**  
01788 534 500  
morgansindall.com

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

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

Global consultants | Designers  
Engineers | Programme managers  
**PARSONS BRINCKERHOFF**  
www.pbworld.com  
services@pbworld.com

**Rutherford global power**  
TEMPORARY ELECTRICAL EQUIPMENT & CABLES FOR TUNNELLING & CONSTRUCTION  
TEL: +44 (0)1206 596 100  
info@rutherfordpower.co.uk  
www.rutherfordglobalpower.com

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

**stirling lloyd**  
THE TECHNOLOGY OF PROTECTION  
SEAMLESS WATERPROOFING TO CREATE WATERTIGHT TUNNELS  
01565 633111  
marketing@stirlinglloyd.com  
www.tunnelwaterproofing.com

**TIMER SOLUTIONS**  
From secured rock to finished tunnel in 8 cm!  
Our shotcrete and mortars setting new standards.  
T: +47 97982850 E: nesheim@tiso.no  
www.tiso.no

**TROLEX**  
www.trox.com  
T: +44 (0)161 483 1435

**URS**  
Multidisciplinary engineering consultancy  
+44 (0)121 212 3035  
uktunnelling@urs.com  
ursglobal.com

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

**VVB Engineering Services Ltd**  
**Mechanical & Electrical Engineering**  
tel +44 (0)1268 711845 | fax +44 (0)1268 711846  
www.vvb-eng.com

PROJECT LOGISTICS  
**W&W** | **ALS**  
WALLENIUS WILHELMSEN LOGISTICS | ABNORMAL LOAD SERVICES  
Tel: +44 (0) 1482 796214  
info.tunnelling@als-europe.com  
www.wwlals.com



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

To advertise here call Tom Willard on +44 (0) 203 096 2608 or email [twillard@tunnelsonline.info](mailto:twillard@tunnelsonline.info)

BORING EQUIPMENT



**TERRATEC**  
www.terratec.co

CHEMICALS



**BASF**  
The Chemical Company  
www.ugc.basf.com

CUTTER TOOLS



**PALMIERI SPA**  
LEADERS IN ROLLER CUTTERS AND TOOLS  
MANUFACTURED FOR ALL TYPES OF TUNNEL BORING MACHINES, MICROTUNNELING UNITS AND VERTICAL DRILLING EQUIPMENT OF ALL MAKES, EITHER STANDARD OR CUSTOM DESIGN  
T: +39 0534 32511 F: +39 0534 32501  
E: [info@palmierigroup.com](mailto:info@palmierigroup.com) W: [www.palmierigroup.com](http://www.palmierigroup.com)  
Agents wanted in selected countries. Please apply to: [a.tasselli@palmierigroup.com](mailto:a.tasselli@palmierigroup.com)

CUTTER TOOLS



**T.B.M. CUTTERS Ltd.**  
DESIGN AND MANUFACTURE OF TBM CUTTING TOOLS AND WEARPARTS CUTTER HEADS MANUFACTURED & MODIFIED  
TEL. +44 (0) 1430 427954 FAX. +44 (0) 1430 427955  
EMAIL. [office@tbmcutters.com](mailto:office@tbmcutters.com) [www.tbmcutters.com](http://www.tbmcutters.com)

DRILL and BLAST



**OSSA**  
OBRAS SUBTERRANEAS  
1952 - 2012  
Polígono Industrial Alcobendas.  
28108 Alcobendas (Madrid)  
T. +34 902 678 808 | F. +34 915 618 894  
[www.ossaint.com](http://www.ossaint.com)

EQUIPMENT

The one-stop source for the tunnelling industry.  
It's only a mouse click from here!  
**tunneltrade.com**  
your tunnel internet portal



**GJERSTAD**  
Our side dumping bucket is the most efficient tool for underground, limited space, work. Mucking out time is reduced by a minimum of 25% compared with other methods. Tyre wear and fuel consumption is also significantly reduced, adding an environmental advantage. More than 90% of tunnel contractors in Norway use Gjerstad side dumping buckets - we deliver all over the world to our customers satisfaction.  
**Rock Solid Solutions** [www.gjerstad.com](http://www.gjerstad.com)

**A.S.T. Bochum**  
Special fittings, hoses and tunnelling equipment  
[www.astbochum.de](http://www.astbochum.de)  
● Erection plant  
● Machine requirements  
● Microtunnelling  
● Drill & Blast tunnelling  
● Air pressure supply  
● Concrete formwork engineering  
● Special civil engineering  
● Shot concrete engineering  
● TBM tunnelling  
● Freezing engineering  
● Wearing protection  
● Pipe-Systems  
Tel. +49 (0)234 / 5 99 63 10 • Fax +49 (0)234 / 5 99 63 20  
[www.astbochum.de](http://www.astbochum.de)

FABRICATION

**TUNNEL STEELWORK SPECIALISTS**  
Cable & pipe brackets, walkways, sleepers and steel fabrications  
**F TRANSFORGE UK LTD**  
www.transforge.co.uk  
+44 (0)1733 249260  
info@transforge.co.uk

FIBRE REINFORCEMENT

**MACCAFERRI**  
Engineering a Better Solution  
Fibre reinforcement | Tunnel drainage | Fibreglass reinforcement  
Self-drilling anchors | Steel arches | Ceramic linings  
[www.maccafferri.com](http://www.maccafferri.com)

DIRECTIONAL DRILLING



**devico**  
DIRECTIONAL CORE DRILLING & BOREHOLE SURVEYING INSTRUMENTS  
Contact us [devico@devico.no](mailto:devico@devico.no) [www.devico.com](http://www.devico.com)

ENGINEERING CONSULTANTS

**Alan Auld GROUP LTD**  
TUNNEL AND SHAFT DESIGN SPECIALISTS  
Telephone +44 (0) 1302 329911  
Fax +44 (0) 1302 329922  
Email [mail@alanauld.co.uk](mailto:mail@alanauld.co.uk)  
Website [www.alanauld.co.uk](http://www.alanauld.co.uk)  
Tunnels - Caverns Foundations - Slopes  
Consultants in Rock Engineering  
**GEO-DESIGN**  
[www.geo-design.co.uk](http://www.geo-design.co.uk)

GROUND CONTROL

**hw hoelscher dewatering**  
· dewatering  
· groundwater control  
· water treatment  
[www.hw-dewatering.com](http://www.hw-dewatering.com)

DYWIDAG-SYSTEMS INTERNATIONAL  
**DSI**  
**ALWAG SYSTEMS**  
GROUND CONTROL SOLUTIONS  
**DSI UNDERGROUND SYSTEMS INC.**  
[www.dsi-tunneling.com](http://www.dsi-tunneling.com)

MICROTUNNELLING

WHEN THE GOING GETS TOUGH...  
...Iseki microtunnelling machines come smiling through!  
Microtunnelling equipment - for hire or sale  
**ISEKI MICROTUNNELLING**  
Iseki Microtunnelling  
Wellingborough UK  
+44(0)1234 781166  
[www.isekimicro.com](http://www.isekimicro.com)

ENGINEERING CONSULTANTS


**geocontrol.es**  
32 años 1982-2014  
**GEOCONTROL**  
BRASIL | CHILE | ESPAÑA | PERÚ  
TUNNEL ENGINEERING  
GEOLOGICAL / GEOTECHNICAL ENGINEERING  
TUNNEL SAFETY INSTALLATIONS  
ROCK MECHANICS APPLIED TO MINING  
TECHNICAL ADVICE DURING CONSTRUCTION  
SITE SUPERVISION  
Cristóbal Bordiú, 19-21, 5º - 28003 Madrid (SP)  
T: +34 91 553 17 63 | F: +34 91 554 93 96  
[geocontrol@geocontrol.es](mailto:geocontrol@geocontrol.es)

**TONY RIDLEY HYPERBARIC ASSOCIATES LTD**  
Consultancy, Expertise and Personnel  
Specialist Tunnelling Services  
Compressed Air - TBM Intervention - Safety - Rescue - Occupational Health  
Tel +44 (0) 1508 538 838 Fax +44 (0) 1508 538 938  
Email [info@hyperbaric-tunnelling.com](mailto:info@hyperbaric-tunnelling.com)  
[www.hyperbaric-tunnelling.com](http://www.hyperbaric-tunnelling.com)

MONITORING SYSTEMS

**Getec**  
Liquid Level Settlement Cells • Monitoring Software • Instrumentation  
[www.getec-uk.com](http://www.getec-uk.com)

PRECAST CONCRETE



**MACRETE**  
028 7965 0471  
[www.macrete.com](http://www.macrete.com)

ENGINEERING CONSULTANTS

Your Trustworthy Tunneling Consultant Since 1962  
CONSULTING ENGINEERS  
**SAANIO & RIEKKOLA OY**  
Laulukuja 4, FI-00420 Helsinki, Finland  
tel. +358 9 530 6540, [www.sroy.fi](http://www.sroy.fi)

EQUIPMENT

**EAVES**  
Tunnel Linings Bespoke Heavy Engineering Solutions  
100 tonne single lift capacity  
0161 223 0400  
[www.eavesmachining.com](http://www.eavesmachining.com)

**Sp SPECIALIST PLANT**  
TUNNELLING EQUIPMENT HIRE AND SUPPLY  
Tunnel Ventilation Systems  
UK Agents for **SVEBRA** LIGHTWEIGHT PIPING  
Tel: +44 (0) 1234 781 882  
Email: [info@specialistplant.co.uk](mailto:info@specialistplant.co.uk)  
[www.specialistplant.co.uk](http://www.specialistplant.co.uk)

MONITORING EQUIPMENT

Tunnel Atmosphere Monitoring  
Carbon Monoxide Nitric Oxide Nitrogen Dioxide Visibility Air Flow & Direction  
Low cost high precision tunnel sensors proven over 20 years  
**CODEL International Ltd**  
World leaders in tunnel atmosphere monitoring  
t: +44 (0) 1629 814351  
e: [sales@codel.co.uk](mailto:sales@codel.co.uk)  
w: [www.codel.co.uk](http://www.codel.co.uk)

Specialists in precast tunnel and shaft systems  
To advertise in the Business Directory contact Tom Willard on +44 20 7406 6599 or email [twillard@tunnelsonline.info](mailto:twillard@tunnelsonline.info)  
Rates, series bookings and dimensions available on request

To advertise here call Tom Willard on +44 (0) 203 096 2608 or email [twillard@tunnelsonline.info](mailto:twillard@tunnelsonline.info)

PIPES and COUPLINGS

**Performance in Piping**  
Quick Connected Steel Pipe System - Corrosion resistant - Low weight - Impressive flow characteristics

ALVENIUS  
Performance in Piping

RAIL and ROLLING STOCK

Maschinen Stahlbau Dresden  
Branch of Henschel AG

Jobsite logistics  
Shaft installations  
Customized back-up systems  
High-performance rolling stock

[www.ms-dresden.de](http://www.ms-dresden.de)

World Leading Locomotives & Haulage Solutions...  
Clayton

...for Mining, Tunnelling & Surface Transport

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

SEGMENT FITTINGS

**TTC**  
TECHNICAL TUNNELLING COMPONENTS

PLASTIC COMPONENTS FOR SEGMENT CONNECTION BUILDING AND GROUTING SYSTEMS

[WWW.TTCLTD.ORG](http://WWW.TTCLTD.ORG)  
+44(0)1455 234401

TUNNELLING SUPPLIES

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

**TA Tunnelling Accessories**

+44 (0) 1424 854112  
[info@tunnellingaccessories.co.uk](mailto:info@tunnellingaccessories.co.uk)  
[www.tunnellingaccessories.co.uk](http://www.tunnellingaccessories.co.uk)

VENTILATION

**NAYLOR**  
AMCO PLASTICS  
Made in the UK  
Excellent Construction Products

WIRE REINFORCED & LAYFLAT TUNNEL DUCTING

T: +44 (0) 1709 872574  
F: +44 (0) 1709 879020  
E: [amcoplastics@naylor.co.uk](mailto:amcoplastics@naylor.co.uk)  
[www.naylor.co.uk](http://www.naylor.co.uk)

**SCHAUBURG**  
TUNNEL-VENTILATION GMBH

Flexible Ventilation Ducting

[www.tunnel-ventilation.de](http://www.tunnel-ventilation.de)  
Phone: +49 208 8827610  
Fax: +49 208 8827615

**SVEBRA**  
LIGHTWEIGHT PIPING

**Quick Coupling Pipes And Fittings**

Strandvägen 25 | 686 30 Sunne, Sweden | T: +46 565 689410 | F: +46 565 711215  
[www.svebra.se](http://www.svebra.se)

RECRUITMENT

**Hunter Personnel**  
Recruiting For Your Industry

**Specialists in Tunnelling and Infrastructure Recruitment**

**VIEW CURRENT VACANCIES ONLINE AT:**  
[www.tunnelsandtunnelling.com](http://www.tunnelsandtunnelling.com)

Contact: David Kellett  
T: +44 (0) 1202 298322 E: [tt@hunterpersonnel.com](mailto:tt@hunterpersonnel.com)  
For more information please go to: [www.hunterpersonnel.com](http://www.hunterpersonnel.com)

**Global Tunnelling Experts.**  
Bringing the best together.

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

Global Tunnelling Experts  
+31 (0) 10 266 94 44  
[clients@global-tunnelling-experts.com](mailto:clients@global-tunnelling-experts.com)  
[www.global-tunnelling-experts.com](http://www.global-tunnelling-experts.com)

The Netherlands | Germany | United Kingdom  
Panama | Denmark | Australia

# What's on

## 2014

**CONEXPO**  
4-8 March 2014  
Las Vegas, USA  
Held every three years, the exposition showcases the latest construction equipment, products, services and technologies. The show will be held at the Las Vegas convention centre.  
[www.conexpoconagg.com](http://www.conexpoconagg.com)

**Eurasia Rail**  
6-8 March 2014  
Istanbul, Turkey  
The Fourth International Rolling Stock, Infrastructure and Logistics Exposition features a tunnel construction section.  
[www.eurasiarail.eu](http://www.eurasiarail.eu)

**ISTSS**  
12-14 March 2014  
Marseille, France  
The Sixth International Symposium on Tunnel Safety and Security in Marseille, France will discuss current best practice and emerging demands and trends as well as research.  
[www.istss.se](http://www.istss.se)

**World Urban Forum Seven**  
5-11 April 2014  
Medellin, Colombia  
The show for the UN-Habitat organisation. The United Nations Human Settlements Programme, UN-HABITAT, is the United Nations agency for human settlements. It is mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities with the goal of providing adequate shelter for all.  
[www.unhabitat.org](http://www.unhabitat.org)

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

**World Tunnel Congress 2014**  
9-15 May 2014  
Iguassu Falls, Brazil

Organised by the Brazilian Tunnelling Committee of the ABMS (the Brazilian Association of Soil Mechanics and Geotechnical Engineering), as well as the International Tunnelling Association, and focusing on "Tunnels for Better Living", WTC 2014 will discuss and illustrate the importance of tunnels.  
[www.wtc2014.com.br](http://www.wtc2014.com.br)

**North American Tunneling Conference**  
22-25 June 2014  
Los Angeles, California  
The US Underground Construction Association (UCA)'s biennial tunnelling conference takes place in Los Angeles, California in 2014.  
[www.smenet.org](http://www.smenet.org)

**InnoTrans**  
23-26 September 2014  
Berlin, Germany  
An international platform for buyers and sellers of passenger and freight transport technology, InnoTrans focuses on railway technology. The Tunnel Construction segment will be accompanied by International Tunnel Forum featuring a series of international discussions  
[www.innotrans.de](http://www.innotrans.de)

**TAC 2014 Annual Conference**  
26-28 October 2014  
Vancouver, British Columbia  
The Tunnelling Association of Canada will hold its conference, Annual General Meeting and Awards at the Sheraton Wall Centre Hotel.  
[www.tunnelcanada.ca](http://www.tunnelcanada.ca)

## 2015

**World Tunnel Congress 2015**  
22-28 May 2015  
Dubrovnik, Croatia  
The jewel of the tunnelling calendar heads to the Dalmatian Coast for the technical event of 2015 as WTC returns to Europe. Details to be confirmed.  
[wtc2015.com](http://wtc2015.com)

**RETC**  
7-10 June 2015  
New Orleans, Louisiana  
The Underground Construction Association's biennial conference.  
[www.smenet.org](http://www.smenet.org)

### British Tunnelling Society

The BTS has a membership of almost 700 individual and 60 corporate members. It is one of the most vibrant gatherings of professional tunnellers in the world and traces its history back to its founding in 1971. Events are hosted at the Institution of Civil Engineers in London from 5.30pm every third Thursday of the month.

**The Use of explosives for New York East Side Access**  
20 February 2014  
The presentation on the use of explosives through the hard granite of the East Side Access (ESA) project in New York will be given by Andy Thompson of consultancy firm Hatch Mott MacDonald.

**High Speed Guangzhou-Shenzhen Hong Kong Railway**  
20 March 2014  
The Contract 824 tunnels will be formed through hard rock using drill and blast techniques over a distance of approximately 2.6km. Permanent shafts (over 90m deep) at either end of Contract 824 for the Ngau Tam Mei Ventilation Building and the Tai Kong Po Emergency Access Point. The majority of the tunnels will be twin bore single track tunnels with an internal span of 7.8m. The scheme also includes a 110m long twin track Crossover Cavern, which will have a maximum internal span of 22m and a maximum internal height of 15m. Two bifurcations with maximum internal spans of 19m for a future spur line are also part of the contract. Speakers are yet to be confirmed.

**C310 Thames Tunnel**  
15 May 2014  
Riku Tauriainen, project director, Andreas Raedle, technical and risk manager, Andy Ingram, construction manager from the Hochtief Murphy JV discuss the geotechnical and tunnelling related specifics in urban tunnelling and river crossing with low overburden.

**What could possibly go wrong with a site investigation in chalk?**  
16 October 2014  
Roy Mortimer of Brighton University reviews case histories and the importance of site investigations and particularly the analysis of the results. To include case histories of good and bad practice.

# Contact us

Jon Young



## Editorial

### Editor

**Jon Young**  
Tel: +44 20 7406 6622  
[jyoung@tunnelsonline.info](mailto:jyoung@tunnelsonline.info)

### Deputy Editor

**Alex Conacher**  
Tel: +44 20 7406 6616  
[aconacher@tunnelsonline.info](mailto:aconacher@tunnelsonline.info)

### Americas Editor

**Nicole Robinson**  
Tel: +1 612 940 2780  
[nrobinson@tunnelsonline.info](mailto:nrobinson@tunnelsonline.info)

### Regular Contributors

**Adrian Greenman, Bernadette Ballantyne, Partick Reynolds, Rhian Owen, Danny Richards**

Alex Conacher



Nicole Robinson



Jim Moore



## Production

### Design/Editorial Production

**David Cooper**

### Production Controller

**Lorraine Lee**  
Tel: +44 20 8269 7799  
Fax: +44 20 8269 7840  
[llee@progressivemediagroup.com](mailto:llee@progressivemediagroup.com)

### Technical Illustrator

**Nick Stenning**

## Sales

### Head of Sales

**Jim Moore**  
Tel: +44 20 7406 6584  
[jmoore@tunnelsonline.info](mailto:jmoore@tunnelsonline.info)

### European Sales

**Randolf Krings**  
Tel: +49 611 5324 416  
Fax: +49 611 5324 519  
[t&t@emcmedia.de](mailto:t&t@emcmedia.de)

### Classified & Recruitment

**Tom Willard**  
Tel: +44 20 7406 6599  
[twillard@tunnelsonline.info](mailto:twillard@tunnelsonline.info)

## Head Office

World Market Intelligence  
John Carpenter House  
7 Carmelite Street  
London EC4Y 0BS  
United Kingdom

Tel: +44 20 7406 6622  
Fax: +44 20 7936 6813

[www.tunnelsonline.info](http://www.tunnelsonline.info)  
[editor@tunnelsonline.info](mailto:editor@tunnelsonline.info)

## BTS - Editorial Advisory Board

**Editorial Advisory Board Chairman:**  
Myles O'Reilly ME, PhD, CEng, FICE  
**Committee:** Keith Bowers MSc, PhD, CEng, FICE, MIMMM, FGS; David Court CEng, FICE; Ivor Thomas BEng, LLB, CEng, MICE; Roger Margerison BSc, CGeol, FGS; Barry M New MSc, PhD, CEng, MICE; Roger Bridge; Andrew Smith BSc, CEng, MICE; Ken Spiby BEng; Eddie Woods BSc, CEng, FICE; Petr Salak MSc, Eur Ing, CEng, MICE; Joanne Sui BEng

## Subscriptions & Reprints

Subscription prices for 12 (24) months:  
Mailed anywhere in Europe €262.50 (€459),  
USA & Canada \$258 (\$258), UK £110 (€188),  
Rest of the world \$316 (\$553).  
Send subscription and back issue queries to  
*Tunnels & Tunnelling* Customer Services.  
[cs@progressivemediagroup.com](mailto:cs@progressivemediagroup.com)

Tel: +44 (0) 845 155 1845 (local rate)  
Fax: +44 (0) 208 269 7277  
[subscriptions@progressivemediagroup.com](mailto:subscriptions@progressivemediagroup.com)  
*Tunnels & Tunnelling* Subscriptions,  
World Market Intelligence,  
Progressive House, 2 Maidstone Road,  
Foots Cray, Sidcup, DA14 5HZ.  
Subscribe online at [www.buythatmag.com](http://www.buythatmag.com)

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

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

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

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

*Tunnels & Tunnelling International* ISSN 1369-3999 is published monthly by Global Trade Media, John Carpenter House, John Carpenter Street, London EC4Y 0AN, UK. The 2012 US annual subscription price is \$ 226 Airfreight and mailing in the USA by agent named Air Business, C/O WorldNet Shipping Inc, 156-15, 146th Avenue, 2nd Floor, Jamaica, New York NY 11434 USA. Periodicals postage pending at Jamaica NY 11431.

US Postmaster: Send address changes to *Tunnels & Tunnelling International* C/O Air Business, C/O WorldNet Shipping Inc, 156-15, 146th Avenue, 2nd Floor, Jamaica, New York NY 11434 USA.

Subscription records are maintained at Global Trade Media, John Carpenter House, John Carpenter Street, London EC4Y 0AN, UK. Air Business Ltd is acting as our mailing agent.

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



# THE PATH OF LEAST RESISTANCE

Carving paths through the earth's most difficult obstacles is already a monumental task. Having an experienced partner that streamlines the entire tunneling operation puts you a step ahead.



**AT ROBBINS WE KNOW TUNNELING IS TOUGH,  
BUT WE BELIEVE YOUR PARTNERSHIPS SHOULDN'T BE.**

Not only does Robbins provide the best designed machine for your project, we offer unrivaled support from project onset to machine buy-back and everything in between. While the underground has no guarantees, partnering with Robbins does.

**Robbins**  
RELIABLE | RESPONSIVE

[THEROBBINSCOMPANY.COM](http://THEROBBINSCOMPANY.COM)