

MARCH 2009

tunnels & tunnelling INTERNATIONAL



FOCUS ON DRILL & BLAST

How the drill & blast sector is dealing with the global economic downturn

SHOTCRETE TECHNOLOGY

The latest offerings from the huge shotcrete market are reviewed



BARCELONA: HERRENKNECHT EPB QUARTET FOR THE LONGEST METRO LINE IN EUROPE.

Barcelona is rapidly extending its metro network. Four Earth Pressure Balance Shields made by Herrenknecht are working to extend line 9 alone, two in the northern and two in the southern section achieving this with excellent top daily performances of up to 60 meters in 24 hours or 1,000 meters in 30 days.

The S-221 (Ø 12,060mm), beginning of tunnelling the largest EPB Shield in the world, has been excavating the northern part of the stretch since 2003. From February 2009 onward, it has been backed up by the S-442 of identical size, which is currently being assembled on the construction site – in a shaft of only 27 meters in diameter. Due to the space constraints, the machine is made up of modules so that the shield can already start tunnelling while the gantries are being assembled gradually.

Following completion of the construction work, line 9 will connect the airport in the south of Barcelona with the northern city district of Santa Coloma de Gramenet. With a total length of 43 kilometers and 49 stations, it will then be the longest metro line in Europe.

BARCELONA | SPAIN

PROJECT DATA

CONTRACTOR

	S-221, EPB Shield Diameter: 12,060mm Driving power: 4,000kW Tunnel length: 1x 3,860m, 1x 1,520m, 1x 3,140m Geology: granodiorite, sand, loam, gravel	U.T.E. GORG (NECSO Entrecanales Cubiertas S.A., Dragados S.A., Sorigue Acsa Obras e Infraestructuras S.A., COMSA - Constructora de Obras Municipales S.A.)
	S-442, EPB Shield Diameter: 12,060mm Driving power: 4,000kW Tunnel length: 3,600m Geology: siltstone, gravel, limestone	U.T.E. GORG (NECSO Entrecanales Cubiertas S.A., Dragados S.A., Sorigue Acsa Obras e Infraestructuras S.A., COMSA - Constructora de Obras Municipales S.A.)
	S-279, EPB Shield Diameter: 9,370mm Driving power: 3,600kW Tunnel length: 1x 1,350m, 1x 8,200m Geology: clay, sand, loam	U.T.E. Tuneses Aeropuerto (FCC Construcción S.A., Ferrovial-Agroman S.A. Obrascón Huarte Lain S.A.)
	S-461, EPB Shield Diameter: 9,370mm Driving power: 3,600kW Tunnel length: 4,107m Geology: sand, clay, silt layers	U.T.E. Tuneladora Metro (FCC Construcción S.A., Ferrovial-Agroman S.A., Obrascón Huarte Lain S.A., Copisa, Scrinser S.A.)



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Boomers still prove the tool of choice for Drill & Blast



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Open wound...

There's bad news for the tunnelling industry this month on p6 - another major collapse on an urban metro scheme resulting in fatalities. This time it's in Cologne with the loss of two lives. Early explanations rely on professional speculation and expert opinion, as it's too early for the official line from the project investigators. Basically, Cologne's city archive building has completely collapsed into a void created next to the site of a nearly completed approximate 30m long x 25m deep open cut box that was to house the Light Metro scheme's track crossover.

The 4km long, north to south metro's twin bore running tunnels were completed over a year and a half ago, at a similar time to the installation of the reportedly 37m deep diaphragm walls, created to support the crossover box excavation. At the time of collapse it's believed that excavation of the box had reached invert level and the base slab was being cast. Currently high on the blame stakes are failure of the diaphragm wall, due to possible ground anchor failure, that was supporting the area in front of the now collapsed building, or invert failure before casting of the base slab was finished. There is also early speculation about the rates of groundwater extraction in the area.

Whatever the reason, it seems a sudden in-rush of heavily water laden, highly variable fluvial ground into the excavated box and running tunnels displaced the ground supporting the adjacent buildings resulting in the total collapse of the archive building.

Already the ramifications are being seen, reports say that the Amsterdam Metro has been put on hold pending further investigations, and

more worrying still, Cologne's Mayor Fritz Schramma has all but said that building metros under densely populated areas is 'irresponsible'.

It's unfair to lay blame so early, we must wait for the official investigation, and then we MUST make the results public if we are to learn to avoid these tragedies in the future.

But here's something to think about in the meantime, as there's a pattern emerging. Let's look at a few recent metro collapses. The Nicoll Highway collapse in Singapore, 20th April 2004, four fatalities, caused by the failure of the supports for the diaphragm walls on the open cut station approach. The Hangzhou Metro collapse in China, 15th November, 21 fatalities, caused by the failure of the concrete walls and steel pipe bracing on the open cut approach to the Xianghu Station. The Cologne Metro collapse in Germany, 3rd March, 2 fatalities, allegedly caused by the failure of the diaphragm walls supporting the open cut excavation for the crossovers.

The hotspots are all large open cut excavations with wall failure - not tunnel collapses. If we can pinpoint the exact reasons for these incidents we are half way to eliminating them. If, as Singapore has done, it requires a radical re-think of temporary works, or even a compulsory over engineered design of such high-risk areas, then so be it. It's time to study all of these disasters together, not separately; the similarities are just too glaring, and iron them out. Then we can go some way to fixing the damage done, not to the works, but to the minds of those that are beginning to see our industry as 'irresponsible'.

Tris Thomas



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Collapse in Cologne

Investigations are ongoing into the fatal building collapse next to a deep, cut-and-cover box excavation below a road at Waidmarkt in Cologne, Germany, for the new North-South light metro line.

Debris collapsed into two holes: where the city's archive building and adjacent structures had stood until 3 March, behind a diaphragm wall of the box structure; and, into part of the box, which at deep levels the rescue services said soil and water had entered, and at the top was partly piled with rubble from the upper levels of the buildings.

Two bodies were recovered

from the building collapse.

Initial reports indicate that the twin bore running tunnels at each side of the box structure - which is to be a cross-over junction, for which excavation was nearing completion for the final slab pour - are partly flooded and filled in stretches with washout soil, but appear to be intact and stable. The ground is being checked between the parallel 7.3m i.d. tunnels.

Concrete was pumped into the Waidmarkt box to help stabilise the site. Dewatering has been underway at 160m³/hr for work to proceed. The geology is gravel, sand and silt, and being not far from the river Rhine the

groundwater level is relatively high.

The North-South line is being developed by Kolner Verkehrs-Betriebe (KVB). The South Lot contractor is a JV of Bilfinger Berger, Wayss & Freytag and Ed Zublin (*T&T*, June 2007, p7).

Bilfinger, leading the JV, declined to comment while the investigations proceed.

Details have not been released yet on any initial conclusions about the collapse mechanism that felled the buildings, and any relationship to the box excavation. No party is officially commenting on those aspects, and responsibility has not been assigned.

Neither was there comment on the failure sequence. However, unconfirmed local media reports say some construction workers from the box excavation, but who declined to be identified, saw water and soil coming in and fled, raising the alarm. Warnings did stop traffic and evacuate the buildings.

Many areas of the visible upper portions of the diaphragm walls appear untouched by the collapse. At one end of the box, just beyond the crater where the building stood, they support steelwork and panels for the roadway, which has also been used by emergency services and construction plant to clearing debris.

Site clearance may take months

with much effort also being spent on retrieving historical records.

The metro line runs from Marktstrasse via six underground station to the main train station. The box is between Severinstrasse and Heumarkt stations.

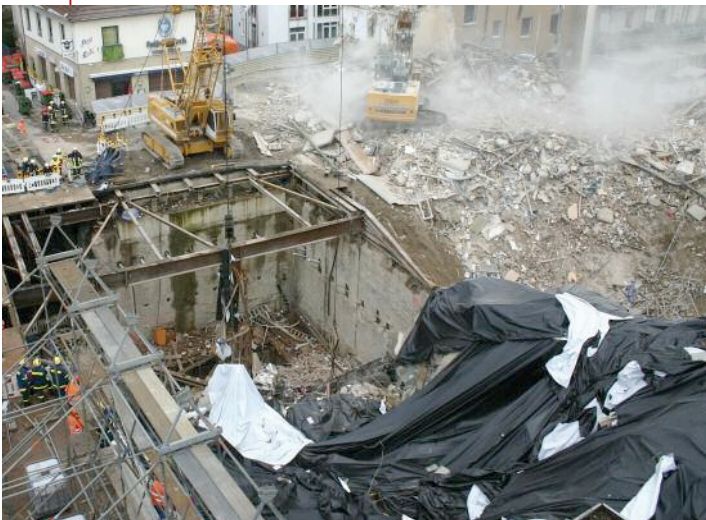
The main works with the stations and bored tunnels, previously completed, in the South Lot called for two 8.39m diameter Mixshield TBM drives, which had cover of 5m-19m along the route.

A variety of construction techniques has been used for different station excavations, including compressed air for breakout of the tubes to reach diaphragm walls.

At Waidmarkt, the diaphragm walls, understood to be 37m-45m deep, were built prior to the passage of the TBMs. Floor slabs and anchors helped support the walls, and the base slab was to be placed at a depth of 28m. Early comments by uninvolved geotechnical experts have focused on possibilities of hydraulic failure below or at the diaphragm wall, though this is speculation, as is the possibility of structural failure.

There was no compensation grouting below buildings in the immediate vicinity, which were not directly over the TBM route.

The City of Cologne said there was unauthorised overpumping in relation to permitted environmental limits. It said the limits were not set in relation to construction safety.



Left: Building collapse next to a metro excavation in Cologne

TBM breakthrough at Lower Inn Valley

The 13m diameter Mixshield driving most of the 5,835m long single bore rail tube for the Lot 3-4 (Munster-Wiesing) section of the Lower Inn Valley, in Austria, holed through last month after approximately 19 months of excavation - and six months faster than first programmed.

Tunnelling with the Herrenknecht TBM (S-352) began at the end of May 2007, just after a year the JV contractor of Porr and Max Bogl began work on the project, which part of the northern rail access to the future Brenner base tunnel.

Geology along the alignment comprises pebble, sand, coarse-grained clay, broken rock and gravel. The drive is almost

completely below groundwater, and cover ranges from 14m to 44m. The TBM has been designed with cutterhead power of 3200kW, torque of 23,230 kNm, and total thrust of 90,515 kN, and for pressures up to 3.6 bar.

In total, the 5,768m long excavation was completed in 585 days. Advances on the best day, week and month were 32.07m, 163.65m and 532.68m, respectively. The 11.63m i.d. segmental rings (7+1) are 500mm thick and 2m long.

The tunnel bore was expected to take about two years, noted the

Right: TBM breakthrough on Lot 3-4, Lower Inn Valley

client, Brenner Eisenbahn GmbH which is part of the Austrian rail company OBB.

The Lot 3-4 section of the Lower Inn Valley is programmed to be completed late next year (*T&T*,

March 2007, p10).

On Lot H8 (Jenbach), the JV of Strabag, Hochtief and Ed Zublin has bored approx 80% of a 3,470m long tunnel with another Mixshield (S-381).





The accelerated progress in sprayed concrete lining (SCL) excavation of the twin bore headings of the A3 Hindhead road tunnels in southern England resulted last month in double breakthroughs well ahead of schedule.

Peak combined progress on all faces – primarily the two SCL drives southwards from the North Portal – was more than 100m per week, said Paul Hoyland, project director. The project has seen the most extensive and complete use of permanent SCL in the UK, the method avoiding the need for lattice arches and steel mesh.

The tube that will take northbound traffic in future had its heading completed three weeks ahead of schedule, and in the southbound bore the breakthrough was 11 weeks early. Good geology

was given as the prime reason for the speed of advance.

In approximately one year, contractor Balfour Beatty has completed the 1,750m and 1,780m long top headings through relatively weak sandstone (2MPa-4MPa) where the profile is just above the historical level of groundwater – a key advantage to the success of the permanent SCL method.

The headings are nominally 11.6m wide and the faces were advanced by Liebherr 944 machines. Cover varies significantly over the alignment, the change being sharpest at 16m-58m over a distance of only 130m. Probing ahead of the main faces and also installation of 4m long self-drilling, glass reinforced plastic (GRP) dowels were done with Sandvik Tamrock Axera 8 rigs. Profile control was supported by VMT.

Hindhead double top

Balfour Beatty now plans to complete the remaining bench and cross passage excavations by late April, before Easter, said Hoyland – well ahead of the plan for a mid-year finish for boring that was in place in the third quarter last year. Tunnel manager on the project is Roger Bridge.

Once the bench dig in the northbound tunnel is completed and the cross-section fully open, as previously planned the tube will keep its wall-mounted conveyor intact for a short time. The equipment will be used to support a major cut and fill operation that will see spoil transferred from outside the South Portal to be deposited out of the North Portal.

A spray-on waterproof membrane and final, non-structural lining will be applied to form a bonded sandwich with the permanent SCL and complete the bored tunnel structure. Concrete

box portals at the ends will complete the twin tubes.

The speed of success of the tunnelling works was not obvious in the early days of the drives from the North Portal when weak, vertical strata was encountered that had eluded the site investigation stage. A contingency had the possibility of more work being done from the South Portal but after a few months the geology improved and got better as the works progressed, in the end giving an opposite experience to the grimmer outlook at the very outset (*T&T*, October 2008, p16-18).

The project is being built on a Target Cost basis and the programme has been to have the new route operational for traffic by August 2011.

The two-lane tubes (10.6m wide finish by 5.28m clearance) have been bored below through a protected area of natural beauty as part of a congestion relief scheme.

Eurotunnel adds to fire safety plan

Plans to install a new fire suppression system for freight trains inside the two running tunnels of the Channel Tunnel have been proposed by Eurotunnel to the controlling authority of the Anglo-French fixed link, the Intergovernmental Commission (IGC).

Eurotunnel has not yet finalised its choice of option or where in the tunnels the system would be located, and said the alternatives were being discussed with the IGC. Neither was the owner and operator able to say at this stage what might be the potential costs or works schedule for the fire safety upgrade works in the 50km long tubes. It added, though, that the works should be able to be phased with ongoing maintenance activities.

Systems being examined include possibilities for using sprinkler, gas or foam, which are already part of the fire safety infrastructure outside of the 7.6m

i.d. running tunnels. Alternative locations for such systems are also being examined, and it has not been determined if they will be spread extensively along the tunnels, placed at intervals or at limited, strategic sites.

At present, emergency safety procedures have freight trains stopping in a tunnel as soon as possible except if in a fire incident. If a blaze is detected, the freight train makes a controlled stop at a specified cross passage location to evacuate passengers and crew to the service tunnel, which runs between the main tubes.

The review of fire safety measures and subsequent improvement plan follows the major fire on a freight train last September, which resulted in significant damage to the segmental concrete lining and fixed equipment in the North running tunnel. It also put one of the crossing's six "Interval" stretches – the 17km long "Interval 6" – out of

action while repairs were undertaken, leaving the Channel Tunnel operating at restricted capacity until it fully re-opened last month (*T&T*, February, p21-23).

Four separate inquiries into the fire are underway, including Eurotunnel's own probe, and no interim formal findings on the cause and propagation of the blaze have been issued. The IGC report is due this September. However, Eurotunnel said some things were evident early on and it decided to act upon the main areas, such as enhancing the system of checking for fires before a freight train enters the tunnel.

A key problem to address is how to improve protection of the tunnel infrastructure and this is a focus of the proposal to IGC. The aim is to contain any freight train fire in a smaller location, lower the intensity and temperature to minimise structural damage, and also enable faster intervention by fire and rescue services.

In the fire last year, the train stopped 11km from the French Portal and it took 75 minutes for the main group firefighters to arrive via the service tunnel. The continued operation of the Supplementary Ventilation System (SVS) after the evacuation made the fire worse and also pushed smoke farther into the tunnels.

Eurotunnel said it wanted the fire safety improvement works done as soon as possible, following satisfactory completion of all necessary tests and approval processes for equipment and procedures.

While changes to the SVS operations will be procedural, and so can be implemented quickly, the physical works will take time. But, should downtime for tunnel repairs be needed it would be much shorter than required for major repairs, such as after the recent incident, and the longer works after the first major blaze, in 1996, in the South Tunnel.

Robbins TBM in Akkoy II triple bore



drive to enable water transfer from the Gokcebel reservoir to the Yasmakli reservoir, the TBM will commence operations with a diameter of 4.8m to construct a tunnel that will have a finished diameter of 4.0m.

The drive started in mid-December 2008 and upon completion the shield is to be stepped down in size.

The following two bores require the shield to be 4.0m diameter and the finished diameter of the tubes will be 3.2m. The lengths of the two tunnels will be 4.8km and 4.0km, respectively.

One bore will tap water from several catchment sources to feed the Gokcebel reservoir, and the other narrower bore will supply the power plant from the Yasmakli reservoir.

Geology along the tunnel alignments comprises andesite, basalt, orthoclase granite, rhyolite, dacite and agglomerate, tuff and breccia.

Rock strengths range from

100MPa-230MPa and tensile strengths 10MPa-23MPa with an average abrasivity index of 4.8, said Robbins.

The shield is fitted with 19" disc cutters. The manufacturer said the change of diameter will see removal and changeover of the outer cutterhead sections of the shield removed as well as bottom and side supports, roof shield, dust shield and gripper shoes. The adaptations are to be made prior to transport of the TBM to the second drive.

Robbins' shield is a refurbished TBM that was previously used, at a larger diameter - 4.8m - by US contractor Affholder when working on the 73rd Street Tunnel in Chicago, in 2002.

Akkoy II is being developed on the Harsit river, in Anatolia in north east Turkey, by Akkoy Energy A.S, which was awarded the development licence by the Government.

Akkoy Energy is part of the Kolin Group, based in Turkey.

Excavation is set to resume on the first run of a triple bore workload set for a Robbins main beam TBM on the Akkoy II hydro scheme in Turkey.

The shield is to bore a succession of headrace tunnels, and the total distance to be

excavated is 15.5km over about two years.

Robbins has supplied the TBM and back-up to local contractor Kolin Construction, and said severe weather had stopped excavation in late January.

Beginning with a 6.7km long

Down for F1 at Donington

A box tunnel is being constructed at Donington Park, in north England, as part of the US\$141M upgrade of the track facilities to take Formula One racing when the British Grand Prix relocates from Silverstone to the site from next year. The reinforced concrete tunnel is being cast and after infill of the trench the racetrack will be restored to traverse the roof of the structure.



SUTTON MOTORSPORTS/PA

Hobson hole through

The Lovat EPBM driving the Hobson diversion of the Orakei sewer in New Zealand has holed through after averaging 114m of bored and lined tunnel per week.

Contractor McConnell-Dowell completed the 2,900m long tunnel in Auckland using a 4.35m diameter mixed face shield (RME170SE Series 23700).

The TBM had a maximum cutterhead speed of 6.4 rpm, maximum torque output of 2,460kNm and tools were interchangeable 15.5" disc cutters and rippers. The shield was designed to work in pressures up to 3 bar.

Geology along the alignment though Orakei Ridge and Hobson Bay comprised mainly clay-rich weak sandstone and siltstone with occasional alluvium and volcanic materials. Cover above the crown was approximately 70m deep, and while the beginning of the drive was under

a residential area the end was close to a live sewer.

Progress rates reached were up to 157m in a week, said Lovat. Tunnelling started in June last year and the contractor worked 112 per week over five production days, which included four 12 hour shifts and one day with 16 hours (two shifts of eight hours). There was no weekend working apart from planned maintenance on Saturdays.

The 3.7m i.d. tunnel is being developed by Watercare, a New Zealand water and wastewater utility, as part of Project Hobson which has a budget of US\$59.6M. Construction of the sewer replacement scheme began in mid-2007.

The project also involves excavation of a 22m diameter by 36m deep shaft for a pumping station, which is due to be finished later this year. The entire scheme is to be completed by mid-2010.



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Seli paces B1 for Rome metro



Above: Steady steps taken by Seli on twin TBM drives for Line B1 of Rome metro, and conveyor installation is planned for next month

A switch in spoil removal from wagons to Continental conveyors for TBM drives at Line B1 of Rome metro is due early next month, but delays at a station ahead has led subcontractor Seli to manage the pace of progress with the shields alternating their advances.

Launched in the middle of last year at Conca D'Oro station, the 6.77m diameter Herrenknecht EPBMs (S-387, S-388) are expected to reach Gondar station by July and August, respectively, but will be stopped outside the bulkhead of the box cut excavation.

Seli is building the 5.8m i.d. twin tunnels, for the main contractor, a JV of Salini and Maire Engineering,

under an approx US\$53.3M contract. The subcontractor is also supplying the TBM back-up, rolling stock and auxiliary equipment (T&T, January 2008, p5).

The TBMs will each drive approximately 3km in total, split into three sections, and be pulled through two stations – Gondar and Annibaliano. The shields will terminate at Bologna station where B1 will interchange with Line B.

Geology comprises recent alluvial strata (compressible clays and silty sands). The depth of groundwater over the tunnels is 7m-18m, and approximately 500m into the excavation they will start to bore below the river Aniene. Pressures expected on drives are

1.2 bar-4.8 bar. The tunnel lining (6+1) has 350mm thick segments.

Seli is working on one TBM at a time and has with only two teams on site. The job has seven-day working, four days with a single 10-hour shift, three says with two eight-hour shifts.

The S-387 shield was first to be launched on the southbound drives and is due to the Gondar schedule was stopped after 110m, having made space behind for assembly of its sister machine. Keeping a step ahead of S-388, the lead TBM resumed its drive in January. By early this month S-388 had advanced almost 610m and then was stopped.

Currently, spoil removal by loco and wagons, and crane. Shortly, upon the completion of the next short leg by S-387, conveyors are to be installed in both tunnels and a vertical conveyor. The lead TBM is to resume its drive in late end April towards Gondar, and once stopped the focus will shift to S-388 to close the gap.

Line B1 is to be extended in tunnel north to Jonio, which will be an interchange with Line D. Preliminary works for the extension are underway by the developer and operator, Roma Metropolitana. A extension further north is planned. The Government has already provided US\$311M for the entire proposed length of B1, which is about half of the budget of the section currently being built.

Wrap for Istanbul sewer bores

The second of the two sewer tunnels in Istanbul has been completed by contractor NTF Construction Co using a Robbins hybrid EPBM.

Excavation of the 3km long Kavacik tunnel was undertaken by the 3.1m diameter TBM which was designed to switch from EPB mode to hard rock tunnelling.

Along the sewer alignments the geology comprises silty clay to shale and limestone with some karstic features, and rock strength ranges from 75MPa-100MPa.

Completion of the second drive, in December, follows a year on from the successful bore of the first, 4.1km long Beykoz tunnel, which commenced in early 2007. The TBM was relaunched to drive the Kavacik sewer tunnel in early 2008.

The shield was fitted with 14" disc cutters and spoil removal is by conveyor in hard rock operations, and tungsten carbide drag bits were for use in EPB mode when non-slurry operation used a screw conveyor to supply muck cars.

Tunnel lining has been placed in two stages – 200m thick segmental concrete lining (5+1) and the 2.2m i.d. after placement on the secondary concrete layer.

Start made for Stafelter road tubes

Tunnel excavation was launched last month at the Stafelter road tunnel, part of the final section of the A7 North Motorway under construction in the Grand-Duche de Luxembourg.

The Stafelter tunnels will be 1,850m long twin tubes of horseshoe-shaped profile. To be driven through sedimentary strata dominated by sandstone, approximately 1,650m of each tunnel will be bored and the

remainder built by cut-and-cover.

The tunnels will each carry two lanes of traffic and be linked by six cross passages at spacings of approximately 260m from the finished portals as well as internally.

Construction is being undertaken by a JV comprising Wayss & Freytag, Max Bogl, Galere, Felix Giorgetti and Tralux. Design studies were undertaken by Luxconsult in collaboration with Lombardi, and the former firm is supervising the

works with TR-Engineering.

Work on the 48-month contract to build the tunnel and associated section of road on the A7 began last September, and tunnel excavation starts this month. The contract value is approximately US\$111M, excl. VAT.

Stafelter is the neighbouring and shallower tunnel to the Grouff bores, which passed through more complicated geology and at steeper slopes. The Grouff tubes

are almost 3km long with 10 cross passages and breakthroughs were achieved in mid-2007. Civil engineering work on the bores and road section are to be completed this year (T&T, August 2007, p11).

The Grouff tunnel is being built by the same JV, the design team also worked on the section. The contract value is approximately US\$223M. The entire new section of A7 is scheduled to be open to traffic in 2011.

Crossrail names Prog Partner

Cross London Rail Links Ltd (CLRL) has named Transcend, the joint venture of Aecom, CH2M Hill and Nichols Group, to be its Programme Partner for the Crossrail scheme.

CLRL said the Programme Partner contract was worth approximately US\$139M. The developer said the overall cost of the East-West rail scheme, involving excavation of a total of 41.5km of 6m i.d. twin tube tunnels by TBM, was US\$22bn.

Announcement of the award notification was followed by a 10-day standstill before the contract could be confirmed.

The Programme Partner is a strategic-level role to help deliver the timely completion of the schedule to satisfactory standards and within budget. Crossrail is due to bring first train services into operation in 2017.

Transcend beat two rival shortlisted JVs to secure the

contract: Bechtel, supported by Halcrow and Systra as supply chain partners; and, Legacy 3, a consortium of Parsons Brinckerhoff, Balfour Beatty Management and Davis Langdon Programme Management.

Separately, the losing groups have been independently shortlisted for the Project Delivery Partner contract, along with two others - Laing O'Rourke Holdings and a JV of Capita Symonds and Northcroft.

The Project Delivery Partner role is to help the client meet standards, time and budget, and provide extra key staff to support the core CLRL team, and bids submitted in January are currently being assessed.

CLRL executive chairman, Douglas Oakervee, called the proposed award of the Programme Partner contract to Transcend 'another landmark moment', and praised the quality, expertise and enthusiasm of the bidders in the two-stage procurement process.

Oakervee steered the development of the project to win Royal Assent for legal authority to build the link as well as the

procurement phase and recruitment of leading senior executives. He becomes interim non-executive chairman from next month when the new chief executive joins - Rob Holden, the chief executive of London and Continental Railways (LCR), which built High Speed One.

Also in recent months, the developer - now part of Transport for London (TfL) - appointed Terry Morgan, chief executive of Tube Lines, to be non-executive chairman. He takes on the responsibility from November.

Preparatory site works for Crossrail commenced in January, at Tottenham Court Road tube station in the West End of London. Main construction activities are programmed to start

next year.

On the procurement of design services, Framework Agreements were awarded at the end of 2008 and gives the winners the right to bid for work packages. A dozen parties were notified: Aedas Group; Atkins; BDP; Capita Symonds; Halcrow; Hyder Consulting (UK); Jacobs Engineering UK; Mott MacDonald; Ove Arup; Parsons Brinckerhoff; Scott Wilson Railways; and, WSP UK.

Procurement is also underway for project oversight services to be provided to the Department for Transport given the large public funds that are being given to the scheme.

DSI acquires Peru's Agrhimerc

The Peru-based underground support systems company Agrhimerc has been acquired by Dywidag-Systems International (DSI), which also launched a local subsidiary DSI Peru to hold the business.

DSI bought the 12-year old business last month and all employees of the Lima-headquartered firm have been transferred to DSI Peru. The general manager of the new unit is Rafael Vizuerra Bellido, who was a co-owner of Agrhimerc.

The business brings newly developed forepoling system to the underground excavation market.

The purchase is the latest acquisition for the expanding group, which is owned by venture company CVC Capital Partners. Recently, DSI bought the Brazilian underground support systems company Fosminas Ancoragens.

In neither case was the price paid for the purchase disclosed.

FCC wins rail job

AJV of FCC and Sando has won a contract to build a section of high-speed rail link in Almeria province, Spain, that calls for 14.6km of tunnelling.

The twin tubes will be bored mostly by EPBM over distances of 5.8km and 5.9km, respectively. The excavation diameter is 10.5m and segmental lining is 500mm thick with PP fibres.

At the southern end the bores are to be advanced by NATM over distances of 1.5km and 1.4km, respectively. Excavation is to be drill and blast as well as conventional mechanical methods. Lining thickness will be 350mm of shotcrete or 500mm of reinforced concrete.

The twin tubes will be linked by 15 cross passages.

The US\$321M contract was awarded by the rail network company (ADIF). The tunnels dominate the Sorbas-Barranco de los Gafarillos section of the high-speed line.

Eurotunnel '08 result up despite fire

Channel Tunnel owner and operator Groupe Eurotunnel SA has reported improved operational results for 2008 after entering into the black for the first time the previous year, and despite the revenue impact of the major fire in the North running tunnel in September.

Earnings before interest, taxes, depreciation and amortisation (Ebitda) was US\$536M, which is up 5% at constant currencies. Revenues and other income improved 4% on the same basis to US\$953M, which is 16% more than the minimum target in the 2007 recovery plan. The company has paid its first dividend to shareholders.

Eurotunnel has proposed that a new fire suppression system for any future freight train incident is fitted in the twin tube running tunnels. Discussions are underway with the controlling authority of the bi-national undersea link, the Intergovernmental Commission (IGC), with various alternatives under discussion.

The new fire-fighting zones may be located at strategic cross passages, as the tunnels are used for evacuation (see p7).

After insurance payments to cover the operational and damage costs of the fire, Eurotunnel said the net impact of the incident on its results for the 12 months was a cost of US\$12.8M. The figure is the level of excess it has to pay against insurance cover of up to US\$1,146M.

The budget for the repair programme, which successfully brought the affected stretch of tunnel back into service last month, was given as approximately US\$76.4M. Late last year the company also gave an estimate of the revenue impact during the last half of September alone as US\$28M. No further figure for the subsequent impact on revenues has been given.

However, in its results, Eurotunnel noted against its revenues that insurance payouts to 31 December 2008, in relation to operating losses only, totalled US\$56M after deducting the excess.

Chairman and chief executive, Jacques Gounon, said in a statement: 'Despite the incident in September, the year 2008 clearly marks the end of financial uncertainty for Eurotunnel.'

Design moves for Helsinki metro

Engineering design work for the Western Metro extension in Helsinki, involving significant tunnel and underground station construction, has been let in packages to a numbers of companies.

Last month the developer and operator, Länsimetro Oy, awarded 14 consultancy contracts for the project to twin tube link between the Finnish cities of Helsinki and Espoo. The contracts ranged from rock engineering and tunnel

design to architecture and M&E.

The entirely underground 13.9km long link will extend west from the present terminus at Ruoholahti to Matinkyla with seven intermediate stations - Lauttasaari, Koivusaari, Keilaniemi, Otaniemi, Tapiola, Niittymaa ad Niittykumpu. Each tunnel has nominal excavated dimensions of 6m wide by 4.9m high.

Two rock engineering contracts were awarded. From Ruoholahti to Keilaniemi (the first

station in Espoo) the studies will be undertaken by FKW. Over the remainder of the line, from Keilaniemi to Matinkyla, the work will be done by Poyry in conjunction with Sito and Fundatec.

FKW is also to undertake geotechnical design work for the Western Metro extension.

The Poyry team will be looking at tunnel engineering, access tunnels and five underground stations, plus HVAC and electrical

engineering for the entire extension. Poyry said the value of its services in the detailed design phase is US\$1.7M.

Last year, Sweco was awarded the approximately US\$12.9M contract for the project management of Helsinki's Western Metro extension (*T&T*, November 2008, p14).

The project budget is approximately US\$904M and the scheme is due for completion by late 2013.

Wirth M&C unit strides ahead

A number of roadheader contracts in Russia, Algeria and Italy, plus a TBM for Sardinia and one despatched for Brazil, have helped the tunnelling activities of the Wirth group to start the year well, it reports.

The tunnelling activities were recently merged with the mining and foundation units to form the mining and construction business. Wirth said the orders were a positive start to 2009.

Wirth received an order for a T3.20 roadheader from Toneldorstroy for excavation work in Sochi, Russia, part of the host city development work for the 2014 Winter Olympics.

Two of the same models were ordered for a rail tunnel project in Algeria. OHL has ordered the machines to help excavate the Ras el Ma and Guessaba tunnels on the Ramdane Djamel to Annaba link.

The T3.20 was also requested by Oberosler for a road tunnel in

Italy. The contractor is building the Val Badia tunnel taking the E66 below Sonnenburg Castle in the southern Tirol and wanted the roadheader with a short lead-time, said Wirth.

An order for a hard rock TBM was place by Todini to bore a rescue tunnel in road tunnel project on Sardinia. The 3.9m diameter gripper is to start boring in October at the Marapintau and Matineddu tunnels on the SS125 between Capo Boi and Terra Mala.

The company has supplied a 6.19m diameter TBM to bore a tunnel for a gap pipeline project in Brazil. The shield will drive a 6km long tunnel through granite and gneiss in the highlands area of Sao Paulo state. The hard rock stretch is part of a 98km long pipeline project.

Excavation with the TBM is scheduled to start in May. The shield was previously used to bore a water supply tunnel in Navarra, in northern Spain.

Seli's Compact ready for Chile

Seli's second Compact DSU is to be despatched this month to Chile to be prepared to help a mining company undertake exploratory drilling for copper ore later this year.

The 4.5m diameter Compact DSU is to be used by the Dragados-Belsaco JV to drive a 8,125m long tunnel at the Los Bronces mine for the site owner, and TBM customer, Anglo American Chile.

Last month the shield was officially inaugurated with both the customer and contractor, and the TBM is expected to start excavation in June. The tunnelling work at the mine is due to be completed after a year.

The value of the contract to Seli to design and supply the Compact DSU plus backup and equipment, and provide specialised workers and technical assistance during excavation, is approximately US\$12.9M.

The Compact DSU is also equipped to install rock bolts, steel set and wire mesh from

below the shield fingers.

Seli developed the tunnelling system to give double shield advantages while being simpler, less expensive, shorter and easy to be dismantled by being bolted, it said. The company made it to work with both NATM and steel segmental linings, be an alternative to the general use of open shields, and become more competitive with heading and bench drives.

The system does not work with concrete segmental lining.

Anglo American Chile announced two years ago that it planned to invest approximately US\$1.7bn to double copper production by 2016.

The Compact DSU system was first used on Italian energy utility Enel's Crevola Toce III hydropower project. Seli has supplied a 4.2m diameter shield for the tunnelling work.

The contractor on the tunnelling project is a Seli-led joint venture with Monti and Giacomini (*T&T*, November 2008, p6).

Swiss road tunnel job awarded to CSC JV

The contract to build the San Fedele road tunnel at Roveredo, in Switzerland, has been awarded to a joint venture led by local firm CSC Impresa Costruzioni.

A 2.4km long, single bore tunnel is being built to enable the N13 national highway to bypass Roveredo, in the canton of

Graubunden.

CSC is a subsidiary of Italy-based construction group Impregilo. Its JV partners in the contract are local firms Frutiger and PraderLosinger.

The JV was awarded the US\$100M contract by the federal roads authority, Ufficio federale delle Strade (Ustra).





Hard-rock Robbins TBM
Ø 9.7 m
Rowa back-up system

TBM for sale

Built 2003
Refurbished 2007

The Robbins TBM 253-309 was built 2003 for the Karahnjúkar Project in Iceland and refurbished in 2007 for the Sigrino Tunnel in Switzerland (2'300 m length). For this tunnel the TBM was equipped with a new back-up system manufactured by Rowa.

Main technical data:

- » boring diameter: 9.7 m
- » power: 3'750 kW / 5'600 kW
- » cutterhead power: 3'000 kW (10 x 300 kW)
- » cutterhead speed: 0 - 8.3 rpm
- » cutterhead thrust: 20'600 kN
- » stroke length: 1.87 m
- » hydraulic system: 150 kW (285, 345 bar)

Contact:
JV CMC
c/o CSC SA, Via Pioda 5
CH – 6900 Lugano, TI
csc@csc-sa.ch
www.csc-sa.ch

Rock support: rock bolts, meshes, beams, shotcrete
Mucking system: continuous conveyor (800 t/h)

The complete technical documentation is available upon request.

DSU COMPACT TBM SYSTEM
Los Bronces - CHILE



BORING THROUGH
FUTURE



www.selitunnel.com

Budapest hosts WTC 2009

On 23-28 May, the international tunnelling industry will assemble in Hungary's capital for what is set to be one of the most successful ITA-AITES World Tunnel Congresses in recent years

With an exceptional response to its calls for papers and a sold out exhibition, the Hungarian organisers of this year's ITA-AITES World Tunnel Congress have worked very hard to bring together all the ingredients for a very successful event in the beautiful and historic city of Budapest.

Following the traditional ITA Welcome Reception on Sunday 24 May, the Congress begins with an Opening Ceremony at 9.00am on Monday, in the newly refurbished Budapest Congress & World Trade Center. Keynote lectures follow, with presentations on European transport policy from EU Deputy Director-General for Transport, Zoltán Kazatsay, risk management by ITA President, Martin Knights, and soft ground tunnelling methods by General Manager of WBI Engineering, Walter Wittke. Parallel Technical Sessions begin on Monday afternoon, and the ITA Secretariat, in co-operation with Piergiorgio Grasso and Eivind

Grøv, have also organised an interesting Open Session for Tuesday morning. A variety of social events and tours have also been arranged, including technical tours to the Budapest Metro construction works (see box).

"We are expecting to attract a large audience for the event, with over 1000 delegates," says Pál Kocsonya, Congress Chair and President of the Hungarian Tunnelling Association. "A total of 180 papers will be presented during the Technical Sessions and we are also expecting about 250 poster presentations." The organisers are also expecting a lot of professionals to attend from Asia, particularly as China and Thailand will both be bidding to host the WTC2012.

T&T will of course be in attendance and, co-incidentally, this May will be celebrating its 40th Anniversary. So we look forward to seeing you, and celebrating with you, at the WTC 2009 in Budapest!

T&T



Above: Budapest's Line 4 Metro works

METRO CONSTRUCTION IN BUDAPEST

The troubled 37-year history of Budapest's Metro Line 4 is well-known, but at long last, in 2007 the construction works finally began. The new line will connect the southwest of the city to the northeast.

The first 7.5km section, between Kelenföldi Railway Station and Eastern Railway Station, is due to be completed in late 2011, comprising 10 stations. The second 3km section (with four stations), between Eastern Railway Station and Bosnyák Square, is to be completed in 2013. With further extensions planned at both ends of the line, its total length will be 15km. The project is co-financed by the Hungarian State and the Budapest Municipality, with supplementary funds from the European Union.

The single-track twin running tunnels are being excavated using two 6m diameter closed-face EPBMs. The machines were launched in the spring of 2007 and an average progress rate of about 15m per day, depending upon soil

conditions, is currently being achieved. Concurrent to TBM excavation, a 300mm thick reinforced concrete segmental lining is being installed.

Due to the relatively shallow depth of the running tunnels, most of the stations are open cut box structures constructed from the surface using diaphragm or piled walls with horizontal steel and concrete structure supports.

Construction works for all 10 stations on Stage 1 are progressing well, with the majority of stations about 40-50% complete. Tunnelling works are currently 50% complete, and the shields have now reached the Danube, which represents the end of tunnelling operations in Buda side of the city.

More information about Budapest's Line 4 Metro construction, including technical tours, will be available at the 2009 ITA World Tunnel Congress, in Budapest this May. For more information or to register on-line visit <http://www.wtc2009.org>.

EXHIBITORS LIST

AFTES Plant & Equipment Branch	Matrics Consult
Amberg Group	Mining Equipment
ARCADIS	Minova CarboTech
Atlas Copco	NFM Technologies
Babendererde Engineers	Normet International
BASF Construction Chemicals	Norwegian Tunnelling Society
Ceresola TLS	Officine Maccaferri
Consorzio Tre	Rascor International
Esse/Rocksoil	S&B Industrial
Denka Chemicals	Minerals
DMT	Schauenburg MAB
DSI	Schauenburg Tunnel-Ventilation
EDILMAC dei F.LLI	Herco Kühltechnik
MACCABELLI	SELI
Encardio-rite	SIKA
Electronics	Sociedade Portuguesa de Geotecnia
Erkat	Soldata
FiReP International	Solexperts
Förmterv	Strabag
Geoconsult	Swietelsky
Geodata Group	Magyarország
Geodata SpA	Swiss Tunnelling Society
Geokon	Systemair
German Belt Systems	The Robbins Company
Goecke	TIWO
Günther Spelsberg	TNO Diana
Herrenknecht	Tunnels & Tunnelling
Hídépít	UVATERV Engineering
INECO TIFSA	Consultants
ITECH	VMT
KrampeHarex FIBRIN	WBI
Lanxess Deutschland	Xella Trockenbau-Systeme
Lovat	
Mapei	
Marioff Corporation	

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Steady future for Drill & Blast

David Wheeldon talks to top Drill & Blast manufacturers Atlas Copco and Sandvik to find out how the international financial crisis is effecting the discipline

Considering how the global economic recession has impacted drill and blast tunnelling, it might be appropriate to dub the sector 'Even Steven'. A downturn in demand due to the economic conditions is being countered by a boost in activity thanks to government funded infrastructure projects. Along with tunnelling in general, it has emerged one of the few industries resistant to the current global economic turmoil. Leading industry figures say what they expect they are losing out in private investment is being made up for by major project investments by governments which are trying to spend their way out of trouble. Instead of bracing themselves for a downturn in trade, the major equipment manufacturers are positioning themselves to take advantage of a burgeoning trade.

Industry experts say the demand for drill and blast tunnelling continues to be driven by its traditional markets, with the biggest appetites for equipment coming from Nordic countries, the European Alps and East Asia. A steady stream of business will flow from projects that are approved or already underway in China, Taiwan, Hong Kong, Spain, Norway and Sweden. Sweden, for example, will continue to require equipment for massive projects like the Northern Link highway project and the 6km rail tunnel (the Citybanan) that will run through the centre of Stockholm. Hong Kong's ongoing Harbour Area Treatment Scheme (HATS) is another of the major national infrastructure projects demanding drill and blast services.

In all, business was good for the industry's two major suppliers, Sandvik and Atlas Copco, last year. Sandvik said



Top: The Atlas Copco XE3 C rig being used by Veidekke at the Northern Link project in Stockholm, Sweden.

Bottom: The Atlas Copco E2 C two boom hydraulic tunnelling and mining rig

"2008 was a record year once again", while activity levels for Atlas Copco's drill and blast in 2008 were reportedly as good as in 2007, with 2009 predicted to continue the trend.

This activity is fuelling the competition between the major players to provide advances in drill and blast technology, equipment and solutions. The challenge

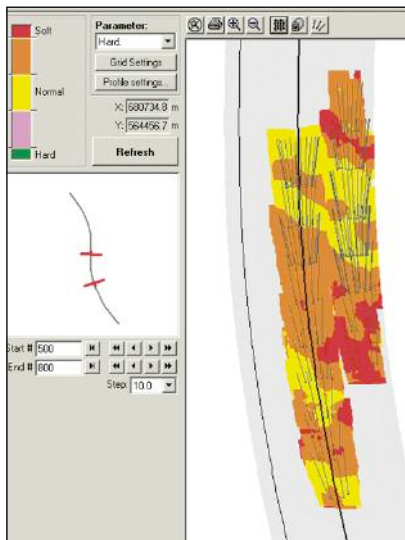
now is to hone the efficiency of hardware and software tools; 2008 saw strong advances in both.

Atlas Copco outlook

Mikael Ramström, product line manager for underground drilling rigs at Atlas Copco's Underground Rock Excavation Division, said their most popular rigs in 2008 were



Above: Atlas Copco's Tunnel Profiler
Below: Atlas Copco's Tunnel Manager MWD in use



the Boomer E-series - more specifically the Boomer XE3 C and Boomer E2 C models.

The Boomer XE3 C is a three-boom hydraulic tunnelling rig with high reach console. Its other features include a fourth generation Rig Control System (RCS) with interactive operators panel and full-colour display; BUT 45 heavy-duty hydraulic booms; COP 1838ME, COP 2238 or COP 3038 rock drills for high-speed drilling; BMH 6800 heavy-duty aluminium feeds with double bottom for high-speed torsional resistance; housed in a sturdy carrier with all-wheel drive. It has a coverage area of up to 198 square metres.

The Boomer E2 C is a two-boom hydraulic tunnelling and mining rig with computer controlled drilling system, which incorporates the BUT 45, with double rotation units for ± 135 degrees feed rotation and ±190 degrees roll-over; and COP 1838ME COP 2238 or COP 3038 rock drills with modern dual-damping system. It also comprises fourth generation RCS, and an ergonomic cabin for the operator's comfort and safety. It has a coverage area up to 137 square metres.

A new development incorporated into the Boomer E-series in 2008 was RHS E Rod Handling System, which Mr Ramström said had proven a highly popular safety enhancement in Nordic countries: "When you use this equipment you can connect a number of drill rods to make longer strings, sometimes up to 25m in length, in order to drill longer holes. Handling these manually is very heavy work, so we introduced a system that makes this process mechanised, so drilling operators don't have to manually handle the heavy drill tools."

An advance in automation technology that the company delivered to the market in

2008 was the Atlas Copco Tunnel Profiler - a fully integrated tunnel profiler for laser scanning of the tunnel profile. This option for the machines allows the operator to see how the actual drill and blast of the tunnel is taking place in relation to the measurements designed. "There are similar systems already on the market, but the good thing about this is that it is fully integrated into with the drilling rig and it's not an add-on system. This is important for improving quality assurance," Mr Ramström said

In 2009 the company has continued to push advances in drill and blast approaches with upgraded versions of the Atlas Copco Tunnel Manager computer programs, which are used for making drill plans and analysing logfiles. Three versions were revised and updated, including the standard Tunnel Manager, the Pro version and MWD - a specialized version used for making deep analysis of rock characteristics in a tunnel.

A component of the software welcomed by engineers is the Drill Plan Generator, which as the name suggests, can automatically generate drill plans based of a set of defined rules. Mr Ramström said: "Some of these plans mean placing more than 100 holes on a drawing; it is very tedious work to sit there and do this. With this tool you can input that you want a certain pattern and it is automatically generated."

According to Atlas Copco the chief areas of interest, as customer demand dictates, remain safety and ergonomics, high precision tunnelling and quality assurance.

The Sandvik view

Sandvik's major advances in 2008 came through its DTi series of tunnelling jumbos which, Pekka Nieminen, Vice President Tunneling and Underground Civil Engineering at Sandvik Mining and Construction said were the company's most popular units in 2008 in terms of sales.

The series includes four different models for excavation of 16-203m² cross sections, including face drilling, bolt hole drilling, and mechanized long-hole drilling. These models were designed for automatic use, and the auto mode works as per the designed drill plan and drilling sequence to add to the predictability of the tunnelling process. For added flexibility in special rock conditions it also includes features allowing the operator to fine-tune the process on line. Lock-to-Target helps the operator to rapidly find the correct hole position, QuickStep allows the operator to affect the operation steps, and Dynamic Correct continuously redirects drilling when the booms are moving, keeping the hole



Sandvik's DTi series drill rig

bottom as planned. The operator can also adjust drilling power level, feed and rotation speed on line when appropriate.

A feature used to add to the accuracy of the DTi series is the boom control. It is based on proven and widely tested deflection compensation but improved further with new features: Roll-over joint and boom location compensation model. The rig's accuracy features also include a new type of front centralizers that offer drill steel guidance in the collaring phase. In addition, the drill bit remains inside the front guide in the collaring; this allows the bit to get as close to the rock as possible.

Another feature added to increase accuracy was the option of advanced factory calibration meant for customer use in job site conditions.

Working conditions and safety were also priorities in the design of the DTi series. The modern, FOPS-certified safety cabin was designed with a 20% larger window surface to give the operators a feeling of space and provide better visibility in all drilling applications, also when the cabin is not elevated. Adding to the visibility is an operator seat placed as close to the windshield as possible, and high power xenon lights for drilling and tramping. Features include an ergonomically designed workstation with armrest integrated controls, efficient air filtration and optimized flow, and noise and vibration suppression.

The components are damage-protected, and to improve ergonomics all daily service points and most of the components were made accessible from the ground level.

The jumbo's "intelligence" features now include condition monitoring and a built-in self-diagnostics system. It comprises onboard diagnostics on screen, graphical representation of component and subsystem statuses, and clear and simple error messages. All events in the control system are recorded for later analysis to help service personnel identify problems and save time. The company says this all leads to significant cost-savings.

With the DTi series in late 2008, the company simultaneously released its own new tunnel planning software, Sandvik iSure, which offers a new way of working with blasting and drilling patterns simultaneously. According to the company, the major benefit of the new software lies on the utilization of the level of hole ends - where the excavation is at its most demanding and where more energy is needed to break and loosen rock - for calculating the hole spacing and burden. The iSure ensures optimized blasting as per plan and supplies better pull-out, decreased need for scaling, increased rock

loadability and smoother collaring in the following round. Sandvik says the economical benefits to users can rise to impressive amounts, thanks to faster advance of tunnel and reduction of overbreak and consequently savings of lining concrete.

One of the new advanced features in the iSure is that it uses explosive power and the specific charging requirements of the different parts of the tunnel cross section, weight and power of explosive charges in holes as well as the depth of the fracture zones as the basis for the drilling and blasting pattern design. Additionally, the fracture zone can be visualised during the preparation of the pattern.

The iSURE produces a review of the drilling process as it offers a possibility to report round, user, service as well as overall performance. The reports offer both a numeric and a graphical display of the results. The program generates visual 3D and diagram presentations of several essential parameters of drilling, offering an MWD tool for excavation process development and rock monitoring development.

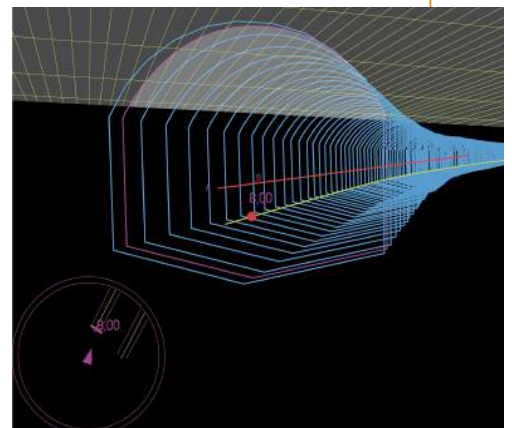
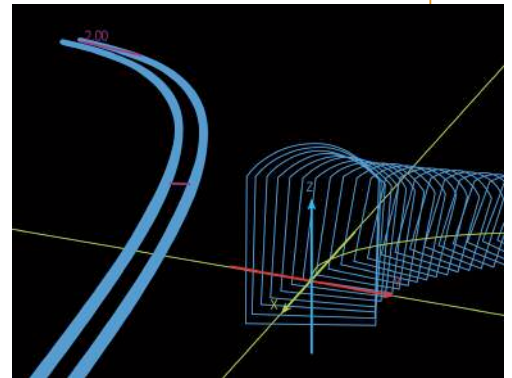
Together, Sandvik says its new software and rigs offer the possibility to define separate drilling parameters for different kinds of holes. This feature allows low power and longer collaring phase for contour holes where accuracy plays a key role and high power for field holes to cut down the round time without sacrificing the profile quality.

Promising outlook

With such new hardware and software being eagerly snapped up off the assembly line, there is strong incentive for the major players to redirect funds into research and development. As is the case with geographical market trends, a few traditional areas demand much of the focus. According to Atlas Copco the chief areas of interest, as customer demand dictates, remain safety and ergonomics, high precision tunnelling and quality assurance.

For Sandvik, Mr Nieminen said safety will remain, "high in the agenda", while "factors such as drilling accuracy, overall performance and user friendliness should not be forgotten".

Both companies emphasised the importance client input plays in developing drill and blast equipment. As Mr Nieminen said: "Various customers participate in the development process before, during and after a development project. In other words, we are in co-operation when mapping the needs and, having launched the product, we naturally collect feedback from the customers."



Above: Sandvik's iSure system offers simultaneous drilling and blasting patterns

As might be expected, both companies remained tight-lipped about potential new developments in 2009. However, Mr Ramström confirmed Atlas Copco was "working on things" and was on track to release new products in spring. At Sandvik, Mr Nieminen said work remained focused on the Sandvik DTi jumbo family and the iSure tunnel planning management software, with new releases coming, but he did not express a timeframe.

In the meantime, the future looks bright for the industry. As Mr Nieminen said from sandvik's perspective: "The tunnelling business is strongly related to infrastructure construction. Therefore, the outlook for us is good as long as the governments and states have money to invest in infrastructure projects."

However the company plans to stay vigilant in mind of the global economic conditions, "we, like everyone else, have to pay attention to our costs and improve efficiency in order to remain competitive in the coming years," Mr Nieminen said.

For Atlas Copco, Mr Ramström agreed the next five years would herald a boom, as long as the plans made by governments "materialised". On the global economic downturn, he said there had been no effect "on the tunnelling sector so far and we do not expect a drop in the near future". T&T

Project Hobson TBM offers greener option

Tom Ireland, Watercare Services Ltd, Rory Bishop, McConnell Dowell Constructors Ltd, and Craig Bourne of Lovat, describe how a TBM option made the Hobson water tunnel a more environmental solution

Project Hobson involves the replacement of a 90-year-old above ground sewer that crosses Hobson Bay in Auckland, New Zealand, and which is nearing the end of its economic life, with a 3km long, 3.7m i.d. segmentally lined bored tunnel.

The US\$60M project will offer several environmental benefits to the Owner, Watercare Services Ltd and the local community by providing capacity to meet projected growth in the region, whilst virtually eliminating wastewater overflows into Hobson Bay and the Waitemata Harbour. It also removes an obtrusive visual feature and opens up the bay for recreational purposes.

When the project was initially conceived during the environmental consenting process, conventional tunnel excavation techniques were envisaged using a roadheader. Due to the presence of two palaeovalleys, which have been infilled with a combination of marine alluvium and volcanic deposits, a deep alignment was required to allow for a conventionally supported tunnel in the siltstones and sandstones of the East Coast Bay Formation (Waitemata Group). This approach resulted

in a pump station over 50m deep and committed Watercare to high operating costs throughout the life of the facility.

During the detailed design phase the decision was made to utilise an EPBM to lift the alignment as high as possible whilst remaining below the most adverse ground conditions - a basalt flow from Little Rangitoto on the eastern side of Hobson Bay. An EPBM was specified to deal with the variable ground conditions, and includes various features to mitigate the risks associated with the higher alignment.

The utilisation of latest TBM technology allowed the alignment to be lifted by around 20m resulting in a significant power saving over the life cycle, and reducing the carbon footprint of the project.

The project

The Hobson Bay sewer services all of the wastewater and part of the stormwater requirements for central Auckland, which is an area estimated to be 3000ha. At present Hobson Bay receives an average of 23 storm-related overflows from the Orakei sewer and branch 1, 2 and 3 sewers a year with an estimated total volume of

16,600m³. Overflows from the existing Pump Station 16 contribute another 30,500m³, making a total of 47,100m³ per annum of overflows to the harbour that are eliminated by the new tunnel.

This new tunnel will receive flows from the Orakei Main Sewer and branch sewers and convey the flows to a new pump station, PS64, which will pump to the Eastern Interceptor. The bored tunnel is approximately 3km long and has an i.d. of 3.7m and o.d. of 4.2m. The tunnel is being constructed using an EPBM capable of operating in open and closed modes. The ground support will be provided using a single pass, precast concrete, bolted and gasketed precast concrete segmental lining. Two (8m and 5m diameter) inlet vortex drop shafts together with a new 22m diameter pumping station will also be constructed as part of the project.

The horizontal alignment commences on the west shoreline of Hobson Bay adjacent to Logan Terrace. Logan Terrace Drop Shaft provides the upstream connection to the existing network. The tunnel crosses the western side of Hobson Bay to the Victoria Avenue Peninsula and then close to the existing foreshore, to connect with Victoria Avenue Drop Shaft. The tunnel continues across the eastern side of Hobson Bay, below the Orakei ridge line to a new pump station (PS64) within the Orakei Domain adjacent to PS16 (figure 1).

Initial Concept

The project was developed by preparing the Assessment of Environmental Effects (AEE) based on a concept design, prior to the commencement of detailed design. The AEE was lodged in March 2004, and consents were issued in November 2006 following a hearing at the Environmental Court.

As stated, the initial concept used in the AEE was for a deep tunnel constructed by conventional tunnelling i.e. a roadheader, in the East Coast Bays Formation thereby avoiding the two infilled alluvial channels that overlie the ECBF in the east and the west of the alignment. At this stage only



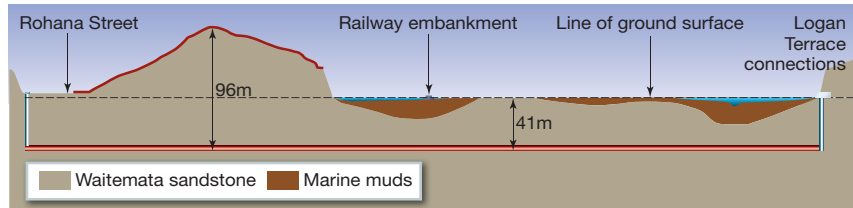
Left: Fig 1 - Project Hobson alignment

preliminary geotechnical investigations had been completed.

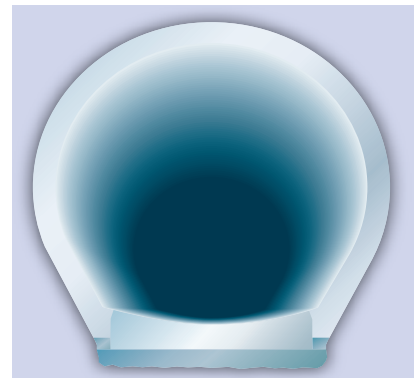
The detailed design of the project commenced during 2005. Key to the project was the depth of the tunnel that would be required to allow conventional excavation, and the incurred high costs associated with the 50m depth of the pumping station.

The decision was then made to utilise TBM technology to lift the alignment as high as possible, whilst remaining below the troublesome basalt flow from Little Rangitoto on the eastern side of Hobson Bay. The strength and consistency of this basalt flow is variable and there is potential for the rock to be water charged. Therefore the risks and TBM performance/configuration requirements to bore through the basalt were not considered acceptable. A tunnel elevation was therefore established to pass below the underside of the basalt. The final alignment was approximately 14m higher than the corresponding roadheader alignment (figure 2).

With the decision to utilise a higher alignment, the geological risk profile for the project increased. The roadheader tunnel (figure 3) would pass through one relatively consistent, and tunnel friendly material, the East Coast Bays formation, whereas the TBM alignment would need to negotiate ECBF, Ash/Tuff, Recent (Holocene)



Above: Fig 2 - Longsection included in the AEE showing depth to invert
 Right: Fig 3 - Roadheader tunnel cross section envisaged in AEE



Alluvium, and Older (Pleistocene and Pliocene) Alluvium.

There was also still an overriding risk of a potential intersection with the Little Rangitoto basalt lava flow even with the higher alignment. Whilst significant geotechnical investigations were undertaken to define the underside of the basalt flow, this is a complex task, as significant variations in basalt depth are possible as the flows fills the erosional surface at the time of the eruption.

The other risks associated with the higher alignment were:

- Tunnelling through mixed face conditions at the unit boundaries
- Tunnel face stability in alluvial units
- Significant water inflows within the ash/tuff units
- Risk of volcanic ejecta (called “bombs”),

which can be made from hard material. These risks were primarily managed through the specification of an EPBM described further below.

Watercare Services Limited also elected to manage and share tunnelling risk through, among other key measures, the implementation of a Geotechnical Baseline Report (GBR) - one of the first uses of this type of document in Australasia^[1].

Baselines for material properties were set

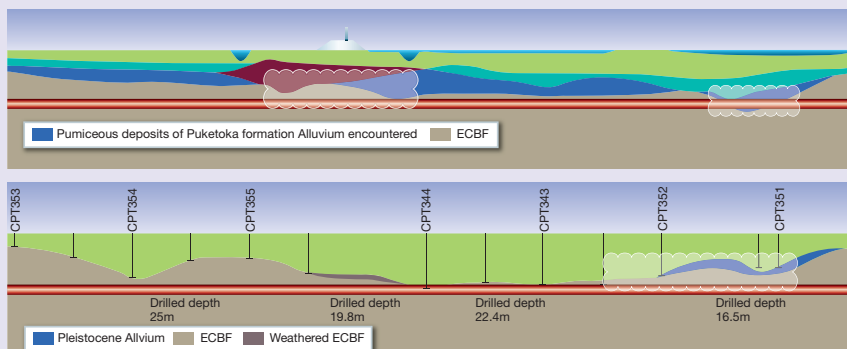
Project Hobson geology

The basement rocks in the Auckland region comprise greywacke and argillite. These are overlain by the Waitemata Group that is divided into a number of distinct subgroups and formations. The East Coast Bays Formation (ECBF) occurs throughout the Hobson Bay area and comprises shallow dipping alternating beds of extremely weak to weak sandstone and siltstone. There are occasional interbedded lenses of Parnell Grit, a weak to moderately strong sandstone. These sediments were deposited approximately 15M years ago in shallow seas and have been subsequently uplifted and eroded to form the foundation of the modern landscape. Intermittent volcanic activity has occurred throughout the region resulting in basalt cones and flows and a number of explosion craters that give rise to local depressions

and tuff deposits. Two main volcanic centres have affected the Hobson Bay area; the Orakei Basin, which has formed as a result of an explosive eruption and coinciding ash and tuff deposits; and the basalt lava flow from the eruption of Little Rangitoto volcano. The ash and lapilli deposits consist of unconsolidated beds of angular to rounded, well sorted, dense to vesicular basalt fragments. When weathered the ash deposits behave like soft to firm, silt and clay. The Tuff consists of very thin graded beds of angular to rounded, well sorted, clay and sand sized ejecta comprising pre-volcanic material as well as basalt fragments. The tuff may be very soft, compacted or welded. When weathered, it can exhibit behavioural characteristics similar to loose to dense sandy or silty gravels.

The basalt lava flow from the eruption of Little Rangitoto, comprises very strong rock, with a fine grained crystalline texture. The top and bottom surfaces of the lava are highly fractured, behaving as a vesicular gravel and cobbles with soft clay and silt infilling. Recent alluvium comprising loose silty sand to very soft silty clay to silty sand, and older alluvium comprising firm to stiff silts and clays of medium to high plasticity and/or dense sands and gravels, has been deposited in the low lying areas.

The top and bottom surfaces of the lava are highly fractured, behaving as a vesicular gravel and cobbles with soft clay and silt infilling. Recent alluvium comprising loose silty sand to very soft silty clay to silty sand, and older alluvium comprising firm to stiff silts and clays of medium to high plasticity and/or dense sands and gravels, has been deposited in the low lying areas.



Top: Eastern Paleovalley detail
 Bottom: Western Paleovalley detail

Table 1

	Orakei Domain	Orakei Ridgeline	East Palaeovalley	Southern section (Victoria Avenue Headland)	West Palaeovalley (Central Section)	West Palaeovalley (Central Section to drop shaft)
Reach						
Chainage (m)	2958 2810	2810 1700	1700 1300	1300 410	410 240	240 5
Length (m)	148	1110	400	890	170	235
Land/marine	Land	Land	Marine	Marine	Marine	Marine
Cover (m)	28	21 - 78	21	21	21	21
Recent alluvium	✗	✗	✗	✗	✓	✗
Older alluvium	✗	✗	✓	✗	✗	✗
Volcanic deposits	✗	✗	✓	✗	✗	✗
Basalt	✗	✗	✗	✗	✗	✗
Soft rock	✓	✓	✓	✓	✓	✓
TBM mode	Startup & trials (closed probing)	Option (open/closed)	Closed	Option(open/closed)	Closed	Option (open/closed)

in terms of the average of a statistically relevant sample. For the driven tunnelling, the drive is broken into geographical units of similar conditions (called “reaches”), as shown in Table 1.

Risk management was undertaken through the specification of mandatory closed mode operation and probe drilling. For example within Reach 3, the tunnel passed through the East Paleovalley, which formed part of Hobson Bay. It was expected that mixed face conditions would be present comprising weathered ECBF, volcanic deposits such as ash and scoria and the older (Pleistocene deposits) muds. It was specified that the TBM should be operated in closed mode within this reach.

Also the geotechnical risks taken by the tenderers was limited where it was felt that better project value was achieved through Watercare taking certain risks. The prime example related to the depth of basalt flow, and this key baseline was set in Reach 3 i.e. the basalt will not be encountered within the tunnel horizon. Forward priced variations were provided to address encountering the basalt (Table 1).

One of the geological units expected to be encountered in Reach 3 is known to contain volcanic ejecta (called “bombs”), which can be made from hard material. A baseline was set to limit the number and size of bombs to be priced. Forward priced

variations were included for encountering more than the baseline number.

For the more consistent Reaches, where the tunnelling face was expected to consist of entirely ECBF, the Contractor was given the option of open or closed mode.

Green benefits of the higher alignment

There are various environmental benefits associated with a higher alignment. The headline environmental benefit is the power savings and the associated savings in carbon emissions. It is estimated that the annual pump power savings is around 3000Mwh which is equivalent to saving of 690t (based on 0.23tCO₂ per Mwh^[2]) of CO₂ per annum^[2] - or removing 150 cars from the road. Thermal Electricity Generation currently represents only one-third of electricity generated in New Zealand^[3] and therefore electricity CO₂ emission rates are low by world standards. If this rate of CO₂ emissions continues through the life of the project, then 69,000t of CO₂ emissions will be saved, although it is worth noting that current government policy is to reduce carbon emissions from electricity generation to nil by 2025.

Other environmental benefits associated with the higher alignment include less waterpressure on the tunnel, and therefore lower leakage rates, leading to savings in treatment costs, and reduced settlement potential. Also the higher alignment requires less use of finite resources such as steel, cement and concrete aggregates required for a deeper pump station and drop shafts.

TBM specification

As part of the risk management undertaken by Watercare for this project, a detailed TBM specification was prepared so that the machines offered by

each of the tenderers adequately addressed the geological risks presented by the higher alignment.

As noted above an EPBM is being used on the project, although the specification also allowed the use of slurry machines. The main potential benefit offered by a slurry machine was the improved performance tunnelling through basalt. Whilst the TBM needed to be designed to tunnel through the basalt, this risk was considered unlikely, and even if required it would be for a short distance.

The requirement for tunnelling through the alluvium in the paleovalleys beneath Hobson Bay meant a closed face machine was required, although the opportunity for both open-mode and closed-mode operation existed on the project.

The fundamental requirements of the TBM to address the geological risks were:

- Face pressure controlled to match the in-situ ground and groundwater pressures
 - Means to measure volumes of excavated material to match advance
 - Continuous grouting of the annular void
 - Minimising of overcutting and loss of ground resulting from steering and directional control
 - Automatic controls to achieve face pressure control, control of excavated volumes, and tail void grouting
 - Tools and cutting head configurations to cover both the expected ground conditions, and the basalt lava flow
- Other specified requirements included:
- Cutting tools shall be replaceable from the rear of the cutterhead
 - Soil conditioning system designed to inject water, foam or another lubricant such as a polymer to the face
 - Computerised laser guided guidance system
 - Guillotine doors to seal within 20 seconds the excavation bulkhead when encountering running ground or flowing water
 - Compressed air system to allow tool changes within soft ground areas
 - Variable drive system for the cutterhead
 - Screw conveyor design to accommodate volcanic block/bombs of 180mm diameter
 - Probe drill to allow 20m to be drilled ahead of the face
 - TBM data collection system

The key to managing the risks presented by the higher alignment related to the possibility of intersecting the basalt lava flow. The team’s approach was to specify a TBM that could tunnel through the basalt using disc cutters if it was encountered. The other key risk was to confirm the depth of the basalt prior to reaching it so that the

Table 2

	Number of rings (1.2m long)	m
Total drive length	2417	2900
Weekly average since commissioning	90	108
Top shift performance	16	19.2
Top daily performance	31	37.2
Top weekly performance	127	152.4
Top monthly performance	500	600

tools could be changed from rippers to discs in free air. It was proposed to confirm the depth of the basalt using probe drilling. Although there are forward price variations within the contract for head interventions under compressed air, from a time, cost and safety perspective this was to be avoided if at all possible.

Contractor, McConnell Dowell Constructors supplied a new Lovat RME170SE 23700 TBM with a cut diameter of 4.353m nominal. The TBM length is 8m and the total length is 70m. The TBM weight is 175t and the total weight is 250t.

Progress to date

TBM tunnelling commenced on programme on 11 June 2008. Tunnelling is undertaken in 8x12hr shifts and 2x8hr shifts per week with a maintenance shift on Saturdays. At the time of writing the machine had 200m to go with completion by the end of January, two weeks ahead of program.

The machine has performed very well, with an availability of over 90% (Table 2),

and has lived up to the reputation of Lovat machines for robustness and reliability.

Conclusion

Project Hobson brings significant environmental benefits to Hobson Bay and Waitamata Harbour. In particular, in the region of 50M litres per annum of wastewater that currently overflows into either Hobson Bay or the harbour will be captured and the recurrence interval for overflows into Hobson Bay increased to 1 in 10 years.

There are also social and cultural benefits associated with removing the existing sewer that that is constructed above the high water level, is visually intrusive and severs the bay.

The application of the latest TBM technology to the project meant the alignment could be raised resulting in an estimated saving of 690t of CO₂ emissions every year which is equivalent to removing 150 cars from the road.

This project is also the first use of an EPBM in New Zealand.

T&T



Above: The Lovat EPBM

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The Pinheiros disagreement

Left: The Pinheiros station collapses in January 2007, killing seven

Dear Sir

I write to *T&T* on behalf of the CVA consortium, which is composed of the five principal Brazilian contractors and two consulting companies. CVA were recently blamed by the Brazilian Technological Research Institute (IPT) team working for the prosecuting authorities, for causing the tragic metro station collapse in São Paulo, which took the lives of seven people in early January, 2007. The authorities nominated IPT and some national and international consultants to perform the 18 months investigations (see resumé in the recent Barros et al., Nov. 08, *T&T* report "Lessons from Brazil: Pinheiros examined"). IPT's official report runs to 3,000 pages and 46 volumes.

I would first like to address *T&T* Editorials of May, 2008 ("Let's get (geo-) physical" by Tris Thomas) and November, 2008 ("Risky business?" by Amanda Foley). *T&T* has understandably tied significant parts of both editorials directly to the two 'opposing-parties' articles, now printed in *T&T*. (The first, by the undersigned, was titled 'A unique metro accident in Brazil', *T&T*, May, 08).

As an international tunnelling consultant having practiced in more than 30 countries, in a wide variety of tropical and undesirably exotic geological conditions, I would have liked to be able to share *T&T* implied belief that 'unforeseen ground conditions' could be virtually removed from the vocabulary of tunnellers. With sufficient access, sufficient (geo)physical techniques, and sufficient time and budget, this ideal could no doubt be approached. Deeper construction of metro stations from underground, would of course be safer in tropical terrains, but clearly not more expensive, as *T&T* suggested in the first editorial. Cities without suitable geology always have to go deeper. Only the escalators and their shafts are more expensive. Stations and metro tunnels are much cheaper, and faster driven when at greater depth, in more uniform geology. One

needs to look no further than London, Prague, Moscow etc. Large-diameter shaft concepts should cease to be a valid construction option, when major construction can be from the underground. Longer escalators are a small price to pay.

As editors of any published material, it is logical that one must believe in material that is submitted for publication. The editorial of November 08, in which *T&T* suggest, based on a synthesis of the IPT-and-consultants article, that "the ground conditions were found to be more or less exactly as predicted at the time of bidding" is understandable in the circumstances in which it was written, taking in good faith the veracity of the submitted article. In view of the fact that painstaking excavation through 16,000m³ of collapsed soil, sand, saprolite, gneiss and mylonite, actually revealed the presence of an undiscovered ridge-of-rock, with top elevations mostly 9 to 11m higher than the evidence of the eleven nearest boreholes, one of them drilled almost in the cavern centre, this conclusion by both IPT and the *T&T* editor has to be challenged. Besides the centre-line hole, the four closest boreholes were drilled immediately around the cavern walls. The real situation was illustrated, in a simplified diagrammatic manner, in the May, 08 *T&T* article referred above.

The above rock-head elevation discrepancy, clearly not as predicted at the time of bidding, is miraculously passed over in the IPT article, and in their 3000 pages report, perhaps because their painstaking drawings of collapsed rock have erroneous (-5m) elevations in relation to the contrary evidence of thousands of photographs, relatively few of which they reproduced. Even after falling 9 to 10m, rock levels were still as high as presumed from borehole evidence. In other locations in the 46 volumes, their dip-and-strike records of jointing show the correct high, central ridge elevations. IPT geologists perhaps did not notice, nor do they comment this discrepancy.

Their report, reflected in the Nov 08 *T&T* resumé, bears witness to many

misunderstandings of rock mechanics principles and tunnel stability concepts, including the idea that the adjacent shaft excavation would reduce, rather than increase the tangential stress acting above the cavern arch. The IPT-and-consultants have also assumed that K_0 of 1.5 is more conservative for cavern stability analyses than the designer's choice of K_0 of 0.33. Their team of geologists, engineers and even professors, also draw incorrect conclusions from some of their own 3D continuum analyses concerning direction-of-excavation effects.

Rock cover was expected to be a mean 3 to 4m above the cavern arch, based on the mean of the five nearest boreholes referred to above. The reality: an inverted wedge or ridge of higher quality rock up to 11m higher, surrounded by weak, weathered material, may have weighed as much as 15,000 tons, taken together with the loading from relic-jointed saprolite. Collectively, this provided the adverse loading in the arch, sufficient both to fail some of the elephant footings at the base of the lattice-girder reinforced 40cm thick S(fr), or to cause yielding and plastic-hinge development of this load-bearing structure, where footings were more resistant. In places, the lattice-girder steel bars of 30mm and 25mm diameter were seen to have been plastically stretched and failed in tension. This matches post collapse modelling with UDEC and structural element force-moment N-M analyses.

Some points in the IPT-and-consultant *T&T* article of November 2008 need particular comment. It is not correct that the rate of excavation accelerated during the excavation of the first bench. It is not correct, due in fact to the number of days lost in the Christmas recess. However, it is normal that bench excavation goes faster than tunnel-front excavation: that is why it is performed throughout the world. It is also normal and expected that increased deformation results. The accelerating deformation shown in the last three to five days prompted additional stabilizing measures by CVA, but even if there had been time to carry these out, failure, with the benefit of post-collapse analysis, would have been inevitable, due to the unprecedented loading.

In view of the eleven nearest boreholes, far exceeding international norms of L(borehole)/L(tunnel) for a 40 x 19m span cavern, both the adjectives 'unpredicted' and 'unpredictable in the circumstances' are probably valid. However, prompted by the relevant (geo)physical observation of *T&T* editor Tris Thomas (May, 2008), we may observe that seismic refraction had been attempted by an IPT team 10 years earlier, on behalf of São Paulo Metrô, in a few locations along quieter (back-street) parts of the line, nevertheless without managing to provide P-wave velocity estimates.

At Pinheiros, the station is immediately adjacent to seven lanes of 24 hours traffic and two rail lines, both key arteries in this 17-million metropolis. Their presence prevented IPT from performing refraction seismic successfully, even after the accident. (Traffic chaos spread out to several kilometres radius, when one of these two parallel arteries was temporarily

closed following the accident). Road closure was not an option for such investigations, and eleven boreholes had not suggested any necessity for such. 'Unpredictable in the circumstances' is probably defensible.

The evidence of eleven boreholes had also not given cause for performing 'noise-protected' (down-hole) cross-hole seismic, a measure that had in fact been used at one location by IPT 10 years earlier. Their nearby (river-margin) boreholes, also used for 3D cross-hole hydro-tomography, had shown a similarly consistent rock head, 14 to 18m below the surface, and a remarkable 20s^{-1} (km/s/km) P-wave velocity-depth gradient, from 2.2 to 4.2km/s in the depth increment 14 to 24m, with Q-values also increasing from about 0.1 to 4 in the space of the same 10m. On

**ANY
COMMENTS?**

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

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the basis of this, potentially favourable footings for the elephant-feet could have been predicted, though the CVA designer chose to be conservative, and not take credit for such.

Sincerely
Dr. Nick Barton, Oslo, Norway

Dubai's 'typical engineering properties'?

Dear Sir

We write with regard to the recent article in the December 2008 Issue of *T&T*, reporting on the British Tunnelling Society Meeting on the Dubai Metro. We found it both interesting and informative.

We are also familiar with the strata reported in the article and have had the opportunity to describe and test these materials on a number of projects in Dubai in recent years. We would like to comment on the "typical engineering properties" listed for the principal strata encountered on the project in Table 1 of the article.

With regard to the shear strength properties, most soils and rocks have a curved failure envelope at low stresses and a cohesion value can be derived from a linear approximation to the curved failure envelope, dependent on the normal stress range selected by the designer. As such the cohesion quoted to 4 decimal places would seem overly precise. The friction angle value quoted for the sandstone strata (18°) is also very low and we would have expected much higher values for a rock made up of cemented carbonate or quartz particles.

With regard to the stiffness properties it would appear that there is some confusion in the units for the properties listed. Whilst

the E' values for the Marine Deposits (in MPa) confirm our expectations, the remaining values of 0.0514MPa to 0.0707MPa do not. Even if the units were in GPa (i.e. 51.4MPa to 70.7MPa) the reported values are considerably lower than we would expect for these strata. By way of illustration we include a plot (our figure 1) of some recent data we have obtained in the sandstone.

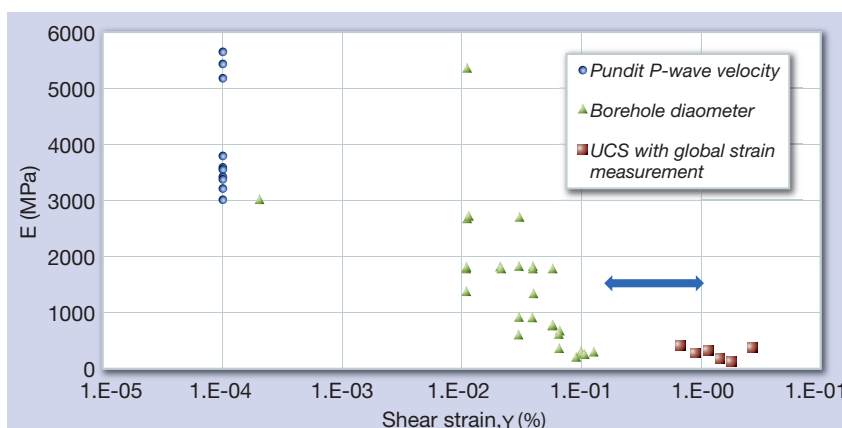
Figure 1 shows the results of a number of tests for Young's modulus, derived from correlations with Pundit P-wave velocity (blue diamonds), borehole dilatometer tests (green triangles) and uniaxial compression tests (orange squares). The strain levels for each test have been converted to an equivalent total engineering shear strain to facilitate direct

comparison between methods. It can be seen that, in common with many other natural soils and rocks, there is a trend of decreasing modulus with increasing strain.

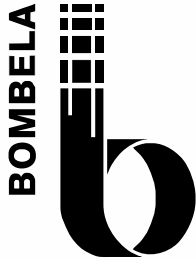
The technical literature suggests that we typically consider modulus values at a strain range of 0.1 to 1.0% for routine tunnel design. From Figure 1 this would suggest that Young's Modulus values in the range of 200MPa to 350MPa could be considered for the sandstone strata. Lower values might be appropriate where the sandstone is poorly cemented and more like a dense sand.

We hope that our comments will be found helpful.

Steve Macklin, Sara Anderson, and Jack Yiu (Arup Geotechnics)



Right: Fig 1 - The author's recent Young's Modulus test results for sandstone



GAUTRAIN SITE DEMOBILIZATION



Bombela Civil Joints Venture consortium, that consists out of Bouygues Civil Works, Murray & Roberts and SPG is currently busy with site demobilization and the following equipment / plant is available:

- COGEMACOUSTIC Tunnel ventilation fan: 30 to 250 kW
- Shotcrete Robot PUTZMEISTER model: PM407 - PM500
- PAUS Dumper ITC 10000 20t payload interchangeable with Concrete mixer CIFA
- Basket NORMET 9915 BA
- LHD GHH Model 6.3
- Batching Plant COUVROT and ARCEN: capacity from 40 to 60 m³/h
- Rolling Stock 900 MM
- FERMEL Utility vehicle
- BOART LONGYEAR Charging Unit
- Grout Pumps CLIVIO
- Agitator Hopper SECATOL: 7m³ - 10 m³
- Gantry Crane: 30 - 40t
- Side tipping bucket GERSTADT. Capacity (3m³ - 4m³)



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“Tunnelling contracts are best implemented based on a Detailed Design procured by the client before tendering the construction contract.”

David Gutteridge opened the debate in support of the motion, by asking the question “So what is a successful tunnelling contract?” David suggested that is where you have a satisfied client and all parties have made a profit (with the exception of lawyers!). This could be achieved by ensuring that everybody had the same objectives and that there was a good technical solution before tunnel construction.

Co-ordinated planning, investigation and design was required, which is about the right people doing the right things at the right time including; reviewing alternatives and options early in the project and not when you have a construction contract in place; establishing a likely construction method; cost and time estimates in place and scheme approvals in place, which if left until award of construction contract could delay the whole scheme.

David suggested that contractors are good at construction and should be left to construct and not design. Clients want to avoid unquantifiable risk, but with design and construct contracts (D&C) the original price often bears no resemblance to the probable outturn price, as the contractor has to include money for this risk. The Client cannot pass on all risk which needs to be considered early in the project by undertaking design before construction. This also leads to the most efficient use of resources. In D&C there may be four or more tenderers all doing the same design which costs money and it is ultimately the Client that will pay for this.

David argued, “All of these objectives are best achieved through assessment of uncertainties through Client design prior to the tender as part of this co-ordinated risk strategy”. This then allows all organisations to be appointed on merit for both design and construction rather than solely on cost. Mr Gutteridge suggested that in D&C contracts there was often more concentration on cost perhaps and not really assessing the risk in the cost.

David stated that detailed design was not necessarily the detailing of every

The motion was presented at the annual BTS debate, and was supported by David Gutteridge, Director Mott MacDonald, and seconded by Sir Alan Muir Wood. The opposition was led by David Fawcett, independent consultant, and seconded by David Hobson, Jacobs Director of Operations for Ground Engineering and Technology

reinforcing bar but it was the whole project being detailed in a sufficient manner to enable it to be built; perhaps 70% design allowing the contractor to adjust the design to suit the method of construction. “This is all part of a continuous project strategy that will lead to a successful outcome, but it also means that ownership of design continues throughout construction and there will be no break in that process”.

David concluded that D&C:

- lacks provision of available data to the client to enable him to assess a fair cost and the contractor has to price for unquantified risk
- makes poor use of combined skills of the whole team and the objectives aren't always the same
- involved more change leading to the design becoming subservient to commercial interests

“If we get it wrong it is good for the lawyers and that is bad for our business.”

“It does not mean that ECI is wrong”

David went on to say, “but that there is a right time to bring contractors in at say 70% design. Nor does it mean that Partnering is wrong as design can still be undertaken in advance of construction. It is bringing people into the partnership arrangement at the right times”

David Fawcett led in opposition to the motion

Mr Fawcett started by saying that Mr Gutteridge had suggested earlier that we would, “Probably be using the same arguments tonight”. Having listened to Mr Gutteridge Mr Fawcett felt, “He was right” but “I have logic on my side”.

We are all well aware that tunnelling is an

art and you never know what you are going to meet which makes it the fun and challenge that we all enjoy. The design must be appropriate for the construction method and only the constructor knows exactly how he is going to build it. For example tunnel lining design where the contractor has redesigned (the original design by a consultant) as it did not fit their TBM or productivity rates. Also with Sprayed Concrete Lining (SCL) “until you are in there and know what the ground is like how on earth can you design it?” The design needs to be coincident and a fully integrated part of the construction process.

“It is sad to say that many designers have never worked at the tunnel face, and therefore it is difficult for many of them to see and fully understand how the design will affect construction.” Over the past 30 years contractors had moved on and now understand design. David believes that the common outcome of a fully engineered design was a large claim which is a completely opposite view to that of the proposer.

Mr Fawcett then went on to describe the process by which a fully engineered design is achieved:

- Brief for designer from Client
- Undertake a Site Investigation, “which is only 0.1% of ground that will be tunnelled through if you are lucky.”
- Create a design based on this investigation
- Job Tendered on basis of this design
- Construction commences and then ground is often not as expected
- Often the specification is not practicable in reality, which leads to a dispute, which is not good for the industry

Mr Fawcett then described the process for Design and Construct:

- Brief for designer
- Site Investigation follows
- Designer then specifies an outline design (10%)
- Contractor is then appointed on a D&C contract

Although Mr Gutteridge said that this D&C tender process was very wasteful, in the experience of Mr Fawcett only about 10% of total design cost is expended at tender stage. There are lots of different ideas that arise and a lot of innovative designs are produced. Contractors and designers work together to develop these innovative solutions. Mr Gutteridge contended this is risky to the Client as the cost is not known but very often these are fixed price contracts and with regard to claims, if the contractor and designer have worked together and done their own investigations there is very little basis for a claim. Therefore, "the Client can know the outcome as he knows someone has specified for him what he wants, and you, to end up with an optimum solution".

Designers and contractors working together as professionals to achieve an optimum solution was a very satisfying process for both parties leading to a satisfied Client.

Mr Fawcett listed several major projects over the last 20 years that used some form of procurement where the design was carried out after the construction contract was awarded and these included The Channel Tunnel; National Grid cable tunnels; DTSS tunnels in Singapore; 2nd Phase SSDS in Hong Kong; Glendoe Hydroelectric Scheme; Oresund Link; A3 Hindhead (EC); Brighton and Hove; Tyne Tunnel; Lee Tunnel; Docklands Light Railway. This demonstrates that many of the major clients such as Eurotunnel, National Grid, Danish, Singapore and Hong Kong governments, SSE, Highways Agency, Southern Water and Thames Water all use design and construct contracts (or a form of them). "Are all of these clients wrong? Are they all dissatisfied?" David was convinced they were not.

Some examples of the use of a fully engineered design in advance were presented including the Jubilee Line Extension where the outturn cost was several orders of magnitude greater than the original estimates; the first stage of the SSDS in Hong Kong where there was lengthy and costly arbitration.

Sir Alan Muir Wood seconded the motion

The main thrust of his support was that the Client needs to have sufficient design to

enable him to understand the project, but not necessarily have all of the detailed design completed. Sir Alan picked up on the Oresund crossing where one of the major successes of this was the initial investigation design undertaken before the contractor became involved so the client understood the fundamental problems and could therefore deal with the risk.

Sir Alan stated that over the last 40 years there had been great strides made in design and construction. He felt it was essential that a designer should understand the essential construction issues of what is being built and in the same way the contractor must be able to engage with the designer so that they can understand the common features of what they are trying to achieve.

The common failings of the last 20 years have been the appointment of engineers advising the Client being made on cost rather than merit. For the success of a project it is essential that, "All parties to a contract have to be treated as professionals."

Sir Alan chose to use the Control of Risk to support the motion. "Tunnelling projects are not inherently risky but they are all accompanied by uncertainties at birth and these have to be perceived as potential risks to be allocated and banished." The Client has to own part of the risk and needs to be involved in the early stages of this process so that they can understand their liability. Clients therefore need to be well informed and in the view of Sir Alan this can only be achieved by them being involved in the design.

Sir Alan described the evolution of the strategy of dealing with employers risk pointing out that there were essentially 3 options:

- Prior to engaging other parties and allocating risk the issues are resolved, eg, ground uncertainties that need additional investigation and dealing with external parties. Sir Alan used the example of the Oresund crossing where one of the benefits of the Client design was that the scheme was agreed with all external parties prior to contractor involvement
- Another option is that the resolution of the uncertainty is delayed until the contractor becomes involved. Design, investigation and treatment are all undertaken at a single stage, which would be associated with the timing of early contractor involvement
- Some risks cannot be expressed such that they can be priced by a contractor and therefore specific provisions need to be made for resolving these, such as the use of reference conditions, defining

special payment terms etc for dealing with these risks. This allows all parties to go into the contract each concerned with benefits of the project and not about how to deal with unquantifiable risk, which would not be the case if the client was not involved in the design

Sir Alan used an example of US procurement models where both the traditional method of procurement was used i.e. client design prior to tender process and a modified approach where the contractor assumes design responsibility. Whilst acknowledging that the client design may be conservative in some cases, with the modified approach there were often a lot of hidden costs included within changes to the design by the Contractor that the Client did not have control over.

David Hobson seconded the opposition

David felt he needed to remind the house of the motion, "Tunnelling contracts are best implemented based on a Detailed Design procured by the client before tendering the construction contract" as the three previous speakers all appeared to be arguing against. This is what often happens when a motion, or indeed a specification clause, is not drafted correctly as you need to redefine it once you start. There has been a redefinition by the previous speakers with Mr Gutteridge defining detailed design as 70% and Sir Alan as "sufficient!" The word "best" was a superlative and on its own was rather arrogant.

He considered the motion was poorly worded and like a poorly worded specification clause was open to interpretation; "This could be a specification clause drawn up by a designer," which had to be reworded by procurement in case it implied a method of construction!

Design means planning, specifying, making sure that it is feasible, viable, cost effective, safe and which is accepted by the client. This needs to be demonstrated before a contract is awarded. "However detailed design means that we have got to physically implement it and produce details that can demonstrate that it can be built safely, cost effectively and is constructable. Who is the best person the deal with when you want to see if something can be constructed?"

The contractor. Therefore he needs to be fully engaged in the detailed design and this ensures that it is designed only once, as you are designing what the contractor wants to build".

“The motion is not only poorly worded but also insulting to contractors as it assumes that the contractor does not bring any value to the detailed design as it is all done before he gets involved”. Contractors do know about design and consultants don’t know it all before tender. Many designers do not get onto site often enough to understand all of the detail of construction. David suggested that we cannot get all of the detailed design right prior to tender so how can it be the “best” thing to do? This is recognised by our insurance colleagues in the codes of risk management which acknowledges that you need to do detailed design during the construction process.

“One of the things that many Clients do not want is a tunnel; they want what goes inside it e.g. railway, cables, an underground store etc.” David agreed that a detailed design could be undertaken for what goes inside the tunnel prior to the tender as what is needed will not change. The one thing that is likely to change though is the design of the tunnel as this is so method and ground dependent.

David concluded, saying the motion is:

- too sweeping,
- poorly constructed and ambiguous like many of our specification clauses;
- Arrogant for designers to say, and says that we have been doing things wrong for the last 20 years and the motion should be rejected.

David Gutteridge summing up in support

Dissection of the motion shows a sign of weakness in the opposers argument as it tries to divert attention of the audience. “The argument put forward by the proposers is really all about risk management, risk identification and uncovering the problems before a contractor comes on board so that there is a fair playing field and a fair result for all, which is often forgotten by those arguing for a D&C process.”

Mr Fawcett presented a long list of D&C projects, but neglected to mention those where the contractor may not have had a similar view to him e.g. Dublin Port Tunnel. Mr Fawcett also mentioned SCL being “designed as it goes.” Whist Mr Gutteridge had no particular objection to the use of the Observational Method, not to have an idea of what you may do if the ground conditions changed by at least having undertaken some design seemed a very risky approach.

“Nothing in the motion actually prevents construction expertise being involved

during the preparation of the design as it refers to the construction contract.” The Hindhead tunnel has been discussed and the design and construction expertise was appointed very early in a combined team and much of this design was complete before the construction commenced which in Mr Gutteridge’s view supports the motion as it is just a different method of procurement.

Mr Gutteridge’s final point was that whether it was design or construction it was about appointing the right people and no matter which method was adopted if the right people were not in place then the job would not be successful. “Appointment on merit, not on cost”. Mr Gutteridge therefore commended the motion to the House.

David Fawcett summing up for opposition

Picking up on contributions from the floor David stated, “risk is not a problem if it is managed.” He also agreed that D&C had put up costs as there was more cost to be built into the tender, however he felt that

cost certainty was more of a priority for many Clients.

It was suggested that contractors do not like D&C and there may be some truth in this due to the increased tendering costs and indeed Mr Fawcett even suggested that many consultants do not like D&C because their costs are often squeezed. However, “it does not mean that it is not the best way of procuring these projects just because the contractors and consultants do not like them – for society it is still the best”.

In response to Mr Gutteridge on the Observational Method, David said that it is not about just going in there and doing it, but is about managing risk.

Getting back to the motion Mr Fawcett felt that supporters of the motion were out of date. He felt that completing the design before tendering the construction contract “was just not how we did it anymore”. With that Mr Fawcett asked the House to oppose the motion.

A vote was carried out by a show of hands and the motion was narrowly defeated.

T&T

QUESTIONS FROM THE FLOOR

Phillip Wilson, Metronet suggested the motion was presented as black and white but none of the speakers really believed this. He compared two M25 widening contracts where the D&C contract came in on time and on budget whereas the detailed design one was 30% over budget.

Mike McConnell, Retired, opposed the motion. He had concerns about the CDM Regulations and how the effect of these can be incorporated at such a late stage. Tunnelling is about practical issues and getting buildability and safety right; how can these be done after 70% of the design is complete. Also getting accurate cost estimates to assist in the selection of the option to construct is not possible without contractor being involved.

Tim Healy, Capita Symonds fully supported the use of early contractor involvement, but this is not much good if the contractor you are talking too does not actually build the scheme. Tim stated that the A3 Hindhead Tunnel was a good model where following a fair tender the contractor has then been involved in detailed design. Worst of both worlds is detailed design by a consultant and then this is handed over to the contractor who has to take responsibility for the design.

Neville Harrison, Consultant Mott MacDonald, stated that Crossrail consulted in

the early days with the leading contractors who indicated that they did not want design and build, so there must be a feeling in the contracting industry that this was not the best way to go.

Tony Walters, Crossrail followed up by stating that in the early days it was Crossrail’s intention to procure as design and construct and indeed through the planning process, before the bill went into the House, this was undertaken by both designers and construction practitioners. Crossrail asked the market and they said they wanted a client design on which they could tender. Tony supported the motion.

Stewart Whittle, Gardiner and Theobald was concerned that there would be insufficient design available prior to tender to allow a client designed scheme to be completed without exposing the client to the risk of large claims.

David Beadman, said Copenhagen Metro was let as a D&C with only a single requirement to deliver a certain number of passengers between these squares per hour which was a very bold specification. The motion is too black and white and he therefore opposed it. However he would support some definition of the tunnel such as diameter, depth etc, and then allow detailed design to be done by a contractor, but not the detailed design of everything.

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Obituary

Sir Alan Muir Wood

In the February issue, on page 7, we announced that Sir Alan Muir Wood had died on 1st February 2009, at the age of 87. His funeral was held on 20th February, at a small church at Ashampstead near Pangbourne and was attended by representatives of the British Tunnelling Society, the Institution of Civil Engineers and the International Tunnelling Association. A Memorial Service will be held on Thursday June 4th 2009 at 1pm at St Margaret's Church, Westminster Abbey, followed by a reception at the Institution. Further details will be announced later.

Sir Alan was not only the most well known tunneller in Britain, but probably in the world. It was excellent that he was at the BTS debate in December last year when he was seconding the motion that was close to 'his heart' (p27).

Early career

Sir Alan was born in 1921 and after a degree from Cambridge University joined the Royal Navy in 1942. After the war he joined Southern Region of British Railways on permanent way, bridge and maintenance works. He investigated the landslips at Folkestone Warren and was responsible for the remedial works.

He joined the Docks and Inland Waterways Executive in 1950, before joining Sir William Halcrow & Partners in 1952, where he worked initially on the design of small diameter rock and soft ground tunnels, particularly GPO cable tunnels, and the rehabilitation of old tunnels in Stockport.

Alan will be especially remembered for his association with the "recent" history of the Channel Tunnel. Between 1958 and 1960 he was the leader of a team that carried out a technical study on the Tunnel, which included the interpretation of available data about the ground and the seabed. He was Project Director for the investigations carried out by Franco - British consultants from 1964 to 1965.

In 1973 to 1975 he was the Halcrow Partner responsible for the joint consultancy team with Mott Hay and Anderson (Mott MacDonald) for the design and construction of the first stage of the Channel Tunnel Service Tunnel before its cancellation in 1975.

In 1981 the House of Commons Transport Select Committee called

upon Sir Alan to be their Specialist Adviser on the Channel Tunnel.

After he retired in 1984 Sir Alan continued to advise Halcrow on the Channel Tunnel before becoming a member of the 5-man Disputes Panel for the Channel Tunnel from 1988 to 1998, thus completing forty years on and off the project.

He was also the Specialist Advisor to the House of Commons Select Committee on the Channel Tunnel Rail Link in 1985 to 1986.

Senior engineer to partner

Sir Alan was appointed a Halcrow Senior Engineer in 1956 and was Project Engineer on two major tunnelling projects:

- The Potters Bar railway tunnels in London Clay where the expanded concrete lining was used for the first time for a large (8.1m) diameter tunnel (1955 to 1959)
- The twin road tunnels under the River Clyde in Glasgow 1955 to 1964

During the downturn in tunnelling Sir Alan was responsible for coastal protection and cliff stabilisation works on the south coast including works at Folkestone Warren where he started his career with British Railways.

He also advised the CEGB on the cooling water tunnels for Dungeness Power Station.

Alan was made a partner of Sir William Halcrow & Partners in

1964. During the next 15 years Sir Alan continued his tunnelling career. He was responsible for the Heathrow Cargo Tunnel (1966 to 1968) the largest expanded concrete lined tunnel, which saved the client 40% of the cost compared to a cast iron lining which would have been used with conventional methods.

This tunnel was 10.3m in internal diameter. Sir Alan had learnt from the Potters Bar tunnels and reduced the thickness of the lining from 0.68m to 0.3m for the much larger diameter tunnel. The tunnel was only 7m below the No. 5 runway which was not closed during the construction. By specifying strict control methods the settlement on the runway was minimised to a face loss of only 0.4% with the maximum settlement of 11mm. There were sceptics who said that the tunnel would collapse and pop out of the ground. It is still there 40 years later and was a project that was completed on time and within budget which a proud Alan always remembered and mentioned at appropriate times.

He was responsible for reports and designs for the British Railways rail link to Heathrow Airport (which was never built) and the early stages of the London Underground Piccadilly Line extension to Heathrow Airport.

Other tunnel projects during this period included studies for road tunnels under Bath to reduce congestion and studies of the

Glasgow Underground. He was a Director of the Orange Fish Tunnel Consultants (South Africa) responsible for the design and construction of the then longest tunnel in the world, 80km, which included sprayed concrete linings.

His other activities included:

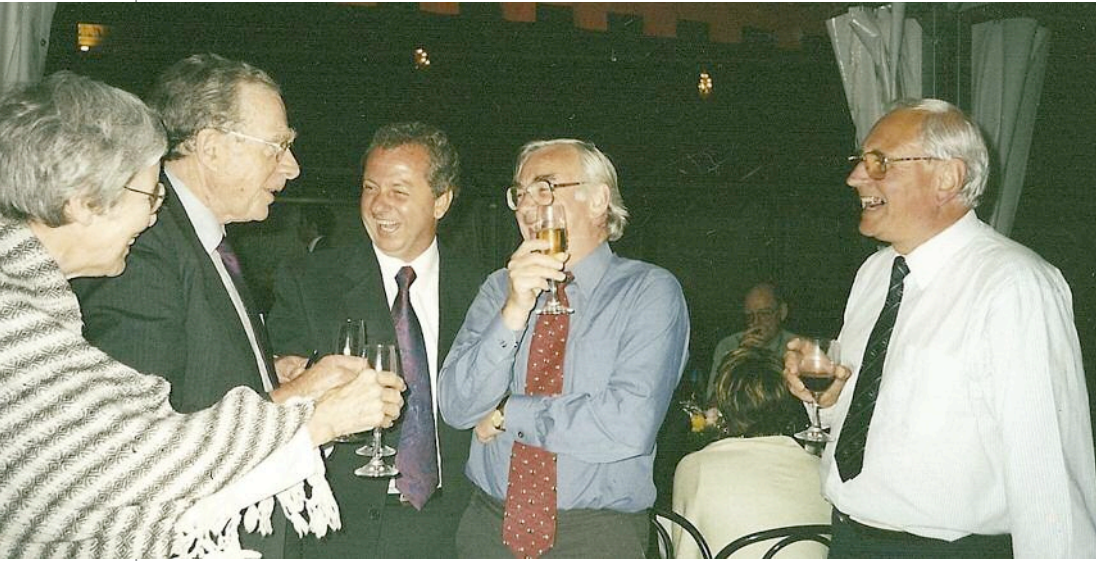
- The investigation of the collapse of the 2,000 tonne steel coal bunker at Sharlston, Yorkshire, and the design and supervision of many reinforced concrete coal bunkers of up to 3,000 tonne capacity
- Responsibility for design and supervision of works to stabilise National Coal Board spoil heaps in South Wales and in North Derbyshire and elsewhere, following the disaster at Aberfan in Wales
- Studies and expert witness for coastal problems and the expert witness for the Government on reinforced earth
- Marine coastal works in the UK, in Greece and the Dominican Republic of Honduras
- Sir Alan was also President of the Institution of Civil Engineers 1977 to 1978

BTS and ITA

In 1970 Alan was Chairman of the OECD Conference in Washington, on tunnelling. He called the conference "this unique conference" as it was the first time that an international conference had been held to advise governments on the policy which they should adopt for tunnelling. The



Obituary



conference led to nations forming their own tunnelling societies.

- The inaugural meeting of the British Tunnelling Society (BTS) was in March 1971 which was attended by 300 people. The late Sir Harold Harding was elected the first Chairman and Alan Muir Wood was elected the second Chairman 1973 – 1974 and is the only person to be elected twice as Chairman (also 1975 – 1976).

Sir Alan was awarded the James Clark Medal jointly with John Bartlett, of Mott MacDonald in 1994 for their services to the industry and gave the Sir Harold Harding Lecture in 2004.

The International Tunnelling Association (ITA) was formed, following the Washington meeting, in 1974 and Sir Alan was elected the first President and in 1977 he was elected Honorary Life President, a post that he held until his death.

The ITA is the family of international tunnellers which meet once a year somewhere around the world. He attended the 25th anniversary in Oslo in 1999 and was at the meeting in Sydney in 2002. He kept in the background and advised the Executive Committee when requested and when carrying out reviews of their structure.

Senior partner to consultant

Alan was appointed Senior Partner of Sir William Halcrow & Partners Ltd in 1979 a position which he held for 5 years until 1984.

He was appointed Knight Bachelor in 1982, for services to engineering.

Sir Alan was responsible for:

- Comparative studies between immersed and bored road

tunnels across the River Thames and the River Orwell at Ipswich

- The Culfail Road Tunnel in Lewes
- Power stations and desalination plants in the Middle East
- Studies for the World Bank of solar energy for small irrigation projects
- Chairman of the Consultants Board for a water interceptor tunnel in Sao Paulo
- Member of the Management Group for British Metro Consultants Group for the Baghdad Metro Project (1981 – 1988)

When Sir Alan completed his term as Senior Partner in 1984 he decided to retire early at the age of 63. He became a consultant to the firm so that he would be able to continue his civil engineering career. He was still actively working until his death. One of his last projects was an adviser on the Gerrards Cross tunnel collapse.

Sir Alan worked for Halcrow for 32 years, 20 of which as a partner. He worked as a consultant for 25 years.

His world wide reputation meant that Sir Alan was asked to work on many projects as an adviser, on Review Boards, as an expert witness and on Disputes Boards including:

- The Singapore North East MRT
- The Sydney Ocean Outfalls
- The ODA Mass Rapid Transit in Developing Countries
- The Health & Safety Executive Enquiry into the Heathrow Collapse
- The Great Belt crossing in Denmark
- He advised the House of Commons on the alignment of the Jubilee Line and a number of

developers which lead to the rerouting of the alignment through Greenwich

- The Heathrow Express cut and cover section through contaminated land
- The management of the Melbourne City Link, and later as an expert witness
- LUL and English Heritage on the treatment of the Brunel Thames Tunnel
- He acted as an expert witness for North West Water Authority during the Abbystead court case
- The Strategic Sewage Disposal scheme in Hong Kong
- Dredging for the Corio Bay Channel in Victoria in Australia, and
- On the risk sharing and disputes resolution panel for the Oresund Crossing between Denmark and Sweden

Sir Alan somehow also found time to write well over 100 articles, papers, books and lectures. He wrote a number of books or chapters on tunnelling. This year he went to press only a week before he died with the article in Civil Engineering on Thomas Young and the Brunels.

There have been many articles on the Channel Tunnel, but the one paper that all tunnellers remember is the March 1975 paper in Geotechnique on “The Circular Tunnel in Elastic Ground” which is the bible for tunnel design. He was the Chairman responsible for the CIRIA Report 79 – Improved Contractual Practices in Tunnelling.

Sir Alan

Sir Alan has made a major contribution to the Civil

Engineering industry. We know him as a tunneller but his other contributions to the industry have been immense. He was one of those rare people who had a thorough grasp of the subject that he could combine both the art and the science of tunnelling. No job was too much and he took on work as he enjoyed it, and was enthusiastic, in solving problems and getting to the bottom of incidents.

He was a “good Engineer” of the old school. People knew that they would be given a fair hearing in any dispute which would be fair, reasoned and not biased.

Sir Alan had some controversial views and therefore his critics and not everyone agreed with him, but he was sincere and gave a good argument and discussion on any topic he believed in.

He had firm views on The New Austrian Tunnelling Method (NATM). As far as he was concerned it was not “new”, not “Austrian” and not really a “method”. He dedicated much time to the advancement of civil engineering and research.

He had very high standards which he expected you also to achieve and was critical, in a kind way, when you did not achieve what he expected you to do. But he always remembered it!

He loved his garden with Winifred, his family, their careers and children. They both love opera and sat through The Ring on a number of occasions.

He received Honorary degrees from four universities and said with a smile that “he was the only amateur doctor in the family.” Lady Winifred and their three sons had earned their doctorates.

- He was a Fellow of the Institution of Civil Engineers
- of the Royal Society
- of the Royal Academy of Engineering
- of Imperial College
- an Honorary Fellow of Peterhouse College, Cambridge and Portsmouth Polytechnic and visiting professor of Bristol University

• He received the Institution of Civil Engineers Gold Medal in 1998

Sir Alan was a friend whom we will all miss, but we will remember him as an inspiration and roll model to us all. His dedication to the Civil Engineering Industry and to Halcrow was exemplary. We give our sincere condolences to Lady Winifred, their three sons and 8 grand children in their great loss.

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- January 3rd**Michael Schumacher the German race car driver is born today
- January 12th**The New York Jets defeat the heavily favored Baltimore Colts 16-7 in Super Bowl III.
- January 20th**Richard Milhous Nixon is sworn in as the 37th President of the United States of America.
- January 30th**The Beatles give their last public performance, on the roof of Apple Records.
- February 9th**The Boeing 747 makes its maiden flight.
- March 2nd**In Toulouse, France the first Concorde test flight is conducted.
- March 28th**Former United States General and President Dwight D. Eisenhower dies after a long illness.
- May 20th**The first issue Tunnels & Tunnelling International is mailed to industry professionals around the world and continues today to provide unparalleled editorial integrity and credibility.
- July 20th**Apollo 11 lands on the lunar surface. Neil Armstrong takes his historic first steps on the moon.
- October 1st**The Beijing Subway begins operation.
- October 16th**New York Mets win the World Series, beating the heavily favored Baltimore Orioles 4 to 1.
- October 21st**Willy Brandt becomes Chancellor of West Germany.
- October 29th**The first message was sent over ARPANET, the forerunner of the internet.
- November 15th**Soviet submarine K-19 collides with the American submarine USS Gato in the Barents Sea.
- November 15th**Regular colour television broadcasts begin on BBC1 and ITV in UK.
- November 19th**Soccer great Pelé scores his 1,000th goal.
- December 15th**Tris Thomas, future editor of Tunnels & Tunnelling celebrates his 1st birthday today!

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3,000 additional copies of this issue will be distributed (8,000 in total) and also made freely available from our stand at following events:

ITA – World tunnel Congress, Budapest, Hungary 23rd – 28th May

RETC, Las Vegas, USA 14th – 17th June

Shotcrete technology - innovation and investment

The wet-mix shotcreting process is well established as the leading method of shotcrete lining installation underground due to the large volumes involved, easier transport of materials over long distances and less dust emission for an improved environment for the operators. Use of compact dry-mix equipment can still be found for small tasks including localised repair. Skilled operators can also adjust the water flow for optimum concrete curing and 'slump' without the use of accelerators. However, most recent innovation for underground use has been aimed at large volume wet-mix work.

One supplier that has been investing is Normet with the establishment last year of its Front Line international operation for sales, marketing and customer service in Switzerland with Tom Melbye, formerly of BASF UGC, as chief operating officer. Other current results of Normet's investment include a new technology centre being built in Finland to enable full-scale prototype manufacture and larger R&D facilities. The Company aims to maintain R&D expenditure at 4% of company turnover. Production capacity is also being increased by two-thirds, and parts storage and control automated, making total investments worth US\$8.8M. The project at Iisalmi, Finland is due for completion in March 2010 after deployment of the machining centre, with assembly of products in the new facilities by August this year.

Recent product developments include the Spraymec 6050 W diesel-hydraulic mobile concrete sprayer within the 6050 series. Aimed mainly at mining, the model can also be used in small tunnel sections. It has maximum coverage of 8m laterally and 9.3m vertically.

With the acquisition in October of the Chile-based Semmco Group, Normet has added that company's range of robotised wet sprayed concrete that Semmco pioneered in Latin America. The range includes the best-selling Alpha 20 mining shotcrete robot. Normet has also set up new regional offices in Australia, Miami - USA and Santiago de Chile as well as the European regional office based with the front line headquarters in Switzerland.

Despite widely fluctuating materials and energy costs, new approaches to sprayed concrete linings seem to be catching on at last. Maurice Jones checks on some of the latest offerings and applications

As part of the BASF Construction Chemicals group, BASF UGC's unusual in being able to offer both shotcreting materials and application plant. This 'full service' approach, together with a regional office and production facility in nearby San Jose, Costa Rica, was a major factor in winning the supply contract for the Changuinola 75 hydroelectric power plant project in Panama. A civils contracting joint venture of E Pihl & Søn and M T Højgaard is

carrying out the construction for AES as owner, with Alstom Brazil as main contractor. The 150MW plant, located in the Changuinola River Basin 345km northwest of Panama City, is due for completion by the end of 2010.

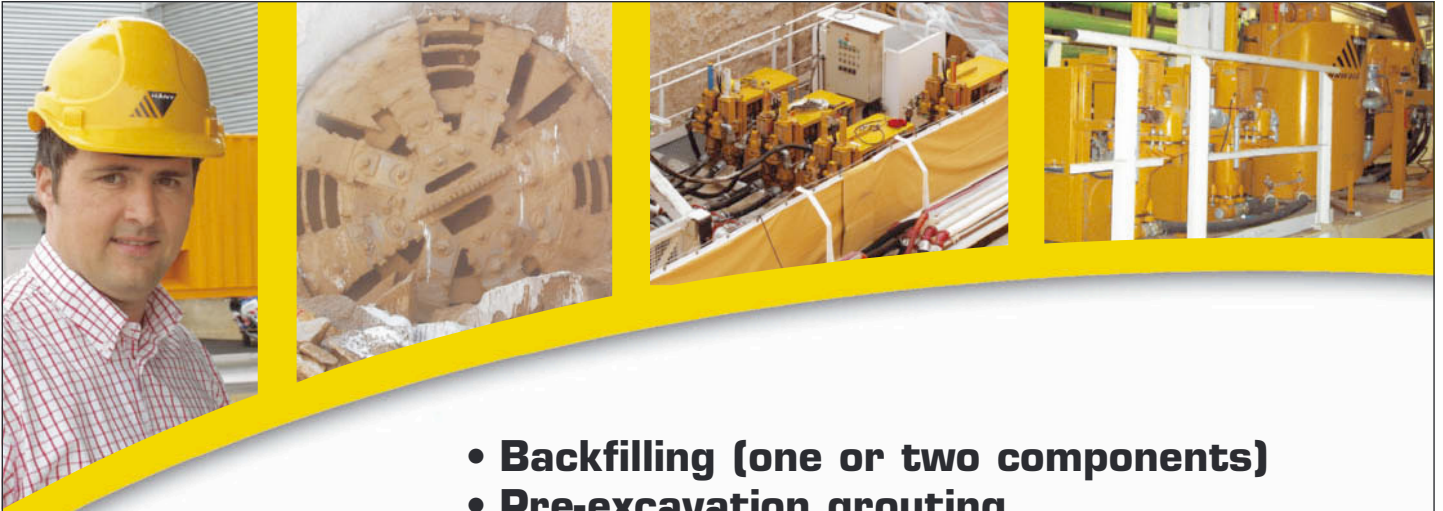
Being an international operation, including having the San Jose base, aided the operation, explained Yves Girard, BASF UGC Manager Caribbean Cluster, based in Puerto Rico. "Being active



Above: The 7000th Normet unit at the launch of investment plans

Below: The second largest rig in the Normet range, the Spraymec 7110 WPC can cover a wide variety of tunnel sections from a rigid carrier with 4-wheel steering





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Above and left: Stabilising slopes on the Changuinola 75 hydroelectric project with a MEYCO Potenza Maxima concrete spraying rig

movement and nozzle positioning compensation. There is also an ability to mark a spraying area and then, in semi-automatic mode, the operator can apply shotcrete along several paths parallel to a predefined axis.

Reinforcement

More efficient reinforcement of shotcrete linings continues to develop, especially with regard to various forms of fibre reinforcement in the concrete mix. A growing and now substantial history of testing and site experience has proven the efficacy of fibre reinforcement made both of steel and polymers. However understandable conservatism amongst many designers may account for some delay in the adoption in fibres, at least of polymer types.

Tests and experience have shown that not only is shotcrete fibre-reinforcement easy to handle and install that steel mesh sheets and similar materials, but the resultant strength of test panels is better or equal than that of shotcrete with mesh reinforcement. The use of suitable polymer fibres has also been shown to deter spalling of tunnel linings under test fire conditions.

Synthetic or polymer fibres are available in micro or macro forms. The first are intended mainly to address early age cracking problems but also offer damage-control advantages under fire conditions. Types are available that allow for an aesthetic surface finish to the concrete without being able to see the fibres themselves in the finished lining.

Polymer macrofibres on the other hand are designed to compete with steel structural fibres but at a lower dosage rate. The latest from Propex Concrete Systems is Fibermesh 650 featuring Propex's e3 technology. The blend of alloy

polypropylene fibres is fixed in length, thickness and mix ration for known engineering properties, and allowing for quick dispersal in the concrete mix. The fibres are claimed to give greater surface area contact with the concrete for increased interfacial bonding and efficient flexural toughness. A wavelike shape of the Fibermesh fibres allows for better anchoring whilst the higher possible dosage rate per volume gives added levels of toughness, energy absorption and durability. In application it is claimed that macro-synthetic fibres give less shotcrete rebound and hence less waste, with thicker one-pass layers being possible.

For example, Andrew Ridout of ElastoPlastic Concrete (EPC) is now able to report several new underground applications of BarChip synthetic fibres in shotcrete mixes. These include the Oliola water tunnel, which is part of the Segarra-Garrigues water transfer canal in northeast Spain. The primary ground support, installed by a joint-venture of Ocean Infrastructures and M y J Gruas, consists of five 2m long rockbolts at one-metre centres, and a 50mm thick lining of shotcrete reinforced with 48mm diameter BarChip Shogun synthetic fibres. The fibres were also used for reinforcing a pre-cast invert and cast in situ secondary lining. The ground supported comprised limestone and greystones with some bands of gypsum.

In Norway 48mm diameter BarChip Kyodo was used in a short but complex upgrade project for the Kykkelsrud-Fossumfoss (FKF) hydroelectric facility on the Glomma River, 13km below Øyeren Lake. Last year contractor Veidekke Entreprenor AS used the reinforced shotcrete plus rockbolts where required to support solid gneiss after drill-and-blast excavation. The shotcrete was produced to performance specification set out by Norwegian Publication No.7 that nominates

Below: At the shotcreted face of the Changuinola 75 HEP headrace tunnel



worldwide had helped us," he said, "as first contact was in 2006 and the equipment discussion started in 2007, not just in Panama on the job site, but also in Denmark between our local underground specialist and the Pihl company."

The order features two BASF UGC Meyco Potenza Maxima remote-controlled mobile spray units to apply approximately 20,000m³ of shotcrete to stabilise surface slopes as well as support the 4.3km long headrace tunnel of horseshoe section. Depending on the ground conditions the support design ranges from class 1 with a 35mm thick layer of fibre-reinforced shotcrete to class 5 with a total of 200mm thick shotcrete placed with lattice girder arches. Ease of operation with minimal movements and maximum coverage are features of the Meyco Maxima Potenza put to great use at Changuinola. The two units were commissioned in June and September 2008 including comprehensive training of mechanical and electrical technicians as well as operators, covering materials as well as use and maintenance of the machines. The Maxima spraying equipment can be used in any tunnel profile that the Potenza carrier can fit into, whilst a long reach permits a large spraying area from a single location, aided by log 'virtual' parallel movement of the spraying head.

Despite sophisticated control features, the 'learning curve' for the Maxima is said to be short. The remote control has a full graphics interface with only two joysticks and a speed control. Computer-managed control facilitates the axis-parallel lance

strength classes of 700 and 1000 Joules total energy absorption in tests. The construction included a 120m long access tunnel constructed on the route of an old aqueduct, and a 70m long tailrace tunnel under the river. The latter has a 110m² section to connect incoming water from a 34m deep shaft to the river, from the turbine gallery. EPC points out that this project is one of those that utilises the non-rusting properties of BarChip fibre since the reinforced shotcrete will be exposed to potentially corrosive water over many years.

A notable project in terms of the modern use of shotcrete technology is the Hindhead Tunnel on the A3 highway in England, which, at the time of going to press, had just broken through. Not only has this project, carried out by Balfour Beatty Major Civil Engineering for the UK Highways Agency, employed various types of synthetic fibre reinforcement in the shotcrete mix, but it also features closely monitored profiling both for roadheader excavation and the shotcreted lining. The twin-bored, 1.9km long tunnel passes under the Devil's Punch Bowl Site of Special Scientific Interest at a maximum depth of 65m. The portals are also supported by shotcrete.

Below: The portals of the new Hindhead Tunnel on England's A3 highway – the entrance to several innovations in shotcreting and close profile control



Other additives

In addition to accelerators to promote early curing with secure layer build-up, other admixtures that may be included in shotcrete include thixotropic materials, hydration controllers and bond improving admixtures. Accelerators are available in different chemical compositions but the preference must be against alkali/caustic forms that can be hazardous to the health of operators.

The properties required of shotcrete mixes can sometimes be complex, demanding an expert knowledge on the part of designers and suppliers on the desired and possible undesirable interaction of admixtures. The scheduling demands of the Gotthard Base Tunnel construction, for example, require the shotcrete mix to be as workable as long as possible, due to the delivery distances, but also to cure when required for early support of the newly exposed rock and for ease of application. Sika's special admixture SikaTard is used to stabilise the concrete mix to ensure that it is workable for up to 8h, whilst Sigunit AF accelerator ensures that strength development of the shotcrete starts on time. The high temperatures and humidity in the long, deep excavations also place extra demands on concrete properties associated with the seeming opposite requirements for long-term workability and early strength characteristics. Sika says that the discovery of high-range water reducers based on polycarbonate ethers (PCE), as used in Sika ViscoCrete, has made concrete more workable and stronger than was possible a few years ago.

Dosing

Accurate measurement, or dosing, of additives to the concrete mix is vital for achieving the required performance of concrete both during application and curing in situ. Chief amongst the materials being dosed in are fibres and accelerators. Not only is measurement important but engineers are requiring proof that the correct proportions have been dosed rather than just waiting for cured concrete test results alone.

Normet's Nordoser 900 H accelerator dosing system can be programmed according to the mix design aided by a 2-colour display and control modules with the latter adjacent to the concrete pump controls. An optional feature on the 900 EH 4G model is a multiple data storage system and a USB data transfer facility for capturing cumulative concrete and accelerator values at a given time.

Standards & Education

EFNARC, the UK-based European Federation of Producers and Applicators of Specialist products for Structures, has been very active in developing standards for the shotcreting industries. At present it is aiming at getting the European certification programme for nozzlemen started this year. To this end the EFNARC General Assembly appointed Janne Lehto, Normet's business line manager for sprayed concrete, as chairman of the Nozzleman Certification Scheme. Lehto was previously a project director with contractor YIT Construction. The aim of the Nozzleman Certification Scheme is to improve the overall quality of sprayed concrete by raising the knowledge and standard of sprayed concrete operators. Candidates are tested in theory and practice at the workplace by an examiner who has a wide experience of underground construction and sprayed concrete and who has been independently accredited by EFNARC. The scheme concentrates on wet-mix, remote control sprayed application and can be adapted to other market sectors where the 'human element' in the installation process is a significant factor.

EFNARC has also recently published a new specification and guidelines for thin sprayed linings for tunnelling and mining. However, this covers non-structural rock support and seals against gas, moisture transfer and weathering, but the thin layer may provide temporary stabilisation and contribute to the overall support such as from reinforced concrete, rockbolts and arches. EFNARC has previously published technical reports and guidelines on sprayed concrete, fire protection in tunnels and viscosity modifying admixtures for concrete.

The American Shotcrete Association (ASA) is also active in practical education to improve standards of shotcreting, having established specific shotcrete nozzleman's training with certification by the American Concrete Institute since a launch in 2001. Requirements include 500h of work experience, pass in a 90min, written examination, and completion of a 2-part performance evaluation including checklist knowledge and creation of an acceptable test panel. The ASA now has a full Underground Shotcrete Education Program led by six approved educators who are all well-known leaders in the industry. The programme covers the basics of the shotcrete process including materials selection and testing, basic equipment requirement, skill requirements

for the nozzlemen and crew, proper shotcreting techniques and safety considerations underground.

Monitoring & observation

While it is completely possible to design a shotcreted tunnel lining from numerical and empirical data (as in the SCL or Sprayed Concrete Lining Method), the lining method is most often associated with observational methods such as the NATM. In these the design of the lining (probably selected from a range of thicknesses and degrees of reinforcement) is determined according to the ground conditions encountered and the reaction of the ground to excavation and primary support measures. Within this process monitoring through instrumentation is vital.

It is also important to check the performance of shotcreted linings in other disciplines such as the SCL method to ensure that lining performance is within design criteria. Engineering practice Mott MacDonald has designed complete monitoring systems and developed

software to generate graphical output for ready understanding of lining performance. The practice has also worked with both Surrey and Southampton Universities on a research

project using pressure cells and related instrumentation to monitor shotcrete lined tunnels. It is also part of the Brite-EURAM III project research into fibre-reinforced shotcrete.

T&T

FURTHER INFORMATION

Some sources of further information related to the above:

1. EFNARC (European Federation for Specialist Construction Chemicals) web-site - www.efnarc.org or e-mail john.fairley@associationhouse.org.uk. New address:
2. EFNARC, Association House, 235 Ash Road, Aldershot, Hampshire GU12 4DD, England; tel.: +44 (0)1252 342072, fax: +333901
3. EFNARC European Specifications for Sprayed Concrete - Checklist for specifiers and contractors - and Guidelines for specifiers and contractors
4. Melbye, T. 'Sprayed concrete for rock support' - published by BASF UGC Sprayed Concrete Association (UK) web-site www.sca.org.uk
5. SCA; 'Introductions to Spayed Concrete' with SCA Code of Good Practice - available from SCA (above)
6. American Concrete Institute web-site www.aci-int.org - publishes 'Certification policies for shotcrete nozzlemen - ACI C 660'
7. American Shotcrete Association web-site www.shotcrete.org
8. ACI Committee 506 'Guide to qualification of shotcrete nozzlemen for specific project' revised
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Products

Abnormal Load Movement

A Herrenknecht tunnel boring machine and ancillaries totalling an enormous 6,000m³ for Barcelona's metro expansion was transported from Germany to Spain using the expertise of project management freight specialists ALS (Freight Management Group) Limited.

The heaviest and one of the highest pieces in the consignment was a shield segment which measured over 7m long, 7.5m wide, almost 4m in height and more than 130 tonnes in weight. In addition a screw conveyor totalling 19m in length, 2m wide, almost 3m high and weighing 84 tonnes was the longest piece transported.

The movement involved local road transportation from Herrenknecht's factory to a

German river port and transhipment to a barge using Herrenknecht's preferred local partner and supervised by ALS' project team from Hull, UK & Moerdijk, Netherlands.

At Barcelona port the TBM and ancillary equipment was offloaded to waiting vehicles and quayside storage area by shore-based cranes, using registered stevedoring personnel and facilities. ALS supervised reloading to trucks from Barcelona Port and transportation to jobsite.

Gary Boden (ALS Operations Manager) and Richard Vellekoop (ALS Branch Manager) have been responsible for the whole project, which has involved: undertaking road surveys, arranging permits, removal of street furniture, barge



movements, sea freight, handling and craneage.

"In view of ALS' experience in similar projects for Herrenknecht which includes the Channel Tunnel Rail Link (CTRL) ALS were appointed to manage the complete TBM movement," Mr Boden said.

Abnormal Loads

Web: www.abnormal-loads.com



TBM Excluder Grease

Tunnel boring machines are consistently getting bigger and quicker and consequently must be sealed efficiently.

BASF Construction Chemicals has entered into the main bearing sealing greases market with immediate effect with the creation of a dedicated production plant. The new product line of MEYCO BSG excluder greases for tunnel boring machines have already been used in significant quantities on selected machines made by the leading manufacturers – with

excellent results. Recently though, Merkel Freudenberg (Germany) and James Walker (UK), said to be the industry's leading main bearing sealing manufacturers, have qualified the MEYCO BSG excluder greases making them appropriate internationally for all operating tunnel boring machines.

The MEYCO BSG excluder greases completes the portfolio of BASF speciality chemicals designed for use with tunnel boring machines which includes:

- MEYCO SLF and Rheosoil soil

- conditioning agents
- MEYCO ABR anti-dust and anti-abrasion agents
- MEYCO TSG tail sealants
- MEYCO GA admixtures for annulus grouts

Furthermore, for this market BASF Construction Chemicals offers MEYCO MP injection products, Rheocem microcements, as well as concrete admixtures for segmental lining.

With this BASF Construction Chemicals believes it has the most complete range of chemical



systems for TBM's. In combination with the technical support of local tunnelling specialists, BASF Construction Chemicals says it is able to offer a fast and all-inclusive service to the tunnelling industry.

BASF Construction Chemicals

Web: www.basf.com

Email: Lars.Langmaack@basf.com



An Atlas Copco XAS186 portable compressor is being employed in vital structural reinforcement work currently underway at the Uskudar underground station of the new tunnel linking Asia and Europe under the Marmara Sea in Istanbul.

Work on the Metro started in 1992 and a short line was operational by 2000, which although just 7km long is transporting up to 70,000 passengers per hour, indicating the urgent need for the extension.

The entirely upgraded and new railway system will be approximately 76km long, with main structures including an immersed tube tunnel, bored tunnels, and cut-and-cover tunnels.

The diaphragm wall at Uskudar, on the Asian side of the tunnel, was erected in 2007 by contractor Bauer as a temporary reinforced concrete structure to allow excavation work. Two Atlas Copco XAS 186 compressors supply air power for the initial bentonite plant.

In addition, Bauer improved the

Compressed workings

subsoil below the foundation level of the underground station with a water-cement mix injected at high pressure through a small-bore hole. This high pressure jet grouting was supported by an Atlas Copco XRVS 476 portable air compressor working at 25 bar and delivering 27.7m³/min.

The north and south diaphragm walls are now 280m long and the west and east sides are each 35m. However, due to the punishing Marmara currents, and poor nature of the sub-soil below the diaphragm, the structure was still deemed unsafe enough to allow the TBM into it to begin excavation.

As a result, sub-contractor Gulsoy Construction Company is

carrying out more reinforcement for the JV main contractors Gama and Nurol. This involves drilling some 125,000 x 40mm diameter holes into the diaphragm structure in order to reinforce it with steel struts and further concrete. An Atlas Copco XAS 186 operating at a pressure of 7 bars and delivering 11.1m³/min is supplying the power for the handheld drilling work now underway.

Once this work is completed, the contractors will have to wait a further year to make certain the structure is totally sound before continuing.

Atlas Copco

Web: www.atlascopco.com

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elsie.vestraets@be.atlascopco.com

GOAD it on



A new Graphic Operator Angle Display (GOAD) system, available on drill jumbos designed by J. H. Fletcher & Co. of Huntington, WV, provides

operators with information that improves accuracy and productivity of drilling. The system uses sensors located on the drill booms and feed mechanisms to

display the angle of drilling and hole depth. When the proper depth is reached, the system automatically retracts the drill.

“By monitoring the angle of drilling, the operator can more accurately align booms for accurate hole placement and direction,” explained Gene Wilson, manager of product development.

“Drill depth and flushing pressure are also monitored. When the proper depth has been reached, or if flushing pressure drops, drilling stops and the drill steel is removed.”

Fletcher is a leading designer and manufacturer of drill jumbos, roof bolters, mobile roof supports, scaling machines, tractors and powder loaders used in underground metal and industrial minerals mines.

J. H. Fletcher & Co
Email: bgoad@jh Fletcher.com.

New drill, new power

Chosen by drilling contractors worldwide for proven reliability and economical operation in underground and surface drilling applications, the Sandvik DE100 range is being expanded. The new Sandvik DE150 is Sandvik’s most powerful exploration drill rig for underground exploration. A surface version is under development and will be ready for market Q4 2009.

The DE150 is powered by a hydraulic motor producing class leading torque of 2000Nm at 485rpm. A hydraulic feed cylinder design gives a push and pull capacity of 15 tonnes (147kN). Depth capacity is up to 2000m (NQ rods). In underground applications the DE150 is powered by a 110kW (150hp) electric power unit giving a maximum working pressure of 250bar (3645psi) and oil flow of 300l/min (79USG/min). For surface application the DE150 can be powered by a diesel engine.

The Sandvik DE150 shares many of the well proven components used by other drill rigs in the DE100-series. The drill unit features a stiff and torsion resistant steel profile feed boom and a direct coupled feed cylinder with a feed length of 1700mm and feed speed of max 0.63m/s. The feed boom is mounted on a frame with tilt cylinder and mechanical supports. The mounting frame has been specifically designed for quick and easy set-up when fan drilling with a full range of adjustment from vertical down to vertical up. The Sandvik DE150 offers exceptional push and pull capacity relative to its weight and size and is also available in steel for environments requiring explosion proof drill units.

Sandvik’s DE150 Torque control enables optimal balance for torque and rotation speed. The control panel is a pilot operated hydraulic system which gives the operator central control of all drilling operations including flush pumps, wireline hoist and boom tilt. The system also controls hydraulic system pressure, feeding force, hold back pressure, water pressure and water flow.

Sandvik Mining and Construction
Web: www.sandvik.com
Email: lars.frandberg@sandvik.com

Pit Boss Pumps

The ARO Fluid Technologies division of Ingersoll Rand Industrial Technologies has released a new line of portable air-operated diaphragm pumps specially developed for mining, construction, sump and other operations where a reliable, dewatering and solids handling pump is an every day requirement. Pit Boss pumps are built to handle the toughest applications while ensuring high flow rates of up to 821L/min. Notably, they are equipped with a diaphragm that the company claims

lasts up to four times longer than competitive models and with a patented air motor that guarantees worry-free operation without ice over or stall out.

Pit BossTM pumps deliver industry-leading performance with powerful suction lift and impressive flow rates to cover the most demanding operations. If semi-solids and solids are an issue, optimized flow passages enable transfer of fluids with particles up to 25.4mm in diameter. Pit BossTM pumps also

have one-way exhaust check valves, enabling submersion if there is a need to place a pump deep in a sump or hole.

Pit BossTM pumps are built to withstand extreme conditions and provide the highest levels of reliability. While other pumps frequently ice over or stall out, the Pit Boss pumps patented air motor designs ensure worry-free operation. A removable screened inlet, furthermore, keeps foreign particles out of the pumps in order to eliminate failure related to pumping debris.

The pumps also feature collapsible comfort-grip handles for convenient portability. They are available in three discreet port sizes. An integrated base plate distributes weight and ensures operation on soggy and unstable terrain.

Air-operated Pit BossTM pumps are intrinsically safe and can be used in hazardous areas and explosive environments without fear of ignition-related sparking.

Pit BossTM pumps are built with serviceability in mind. Bolted construction allows for faster and easier maintenance, especially compared to competitive models featuring band clamps. Readily available service kits are also provided.

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Dates & Events

11-12 MARCH

Multi-System Utility Tunnels (MUT) Haifa, Israel

The first international conference in the developing field of design and construction of underground multi-system utility tunnels (MUTs) will present existing experience regarding planning and construction in Haifa and other towns worldwide. Contact: Diesenhaus Unitours; tel: +972 3 5651324; email: conven4@diesenhaus.com; web: <http://www.multiutilitytunnels.com/>

26-27 MARCH

China Tunnel Summit 2009 Beijing, China

The China Tunnel Summit aims to provide a platform for discussion of new tunneling technologies and challenges in a warm and professional atmosphere. This year's Summit will focus on Safety in Construction and Sustainable Development. Contact: Merisis; tel: +86 21 6247 8608; email: marketing@merisis-asia.com; web: <http://www.merisis-asia.com/tunnel/>

18-20 MAY

8th Iranian Conference on Tunneling and Underground Spaces Tehran, Iran

"Underground Spaces for Safety, Better Environment and Energy" is the theme for this year's conference, which aims to offer a platform for exchange of knowledge and information on state of the art tunnelling development and practices. Contact: IRTA; tel: +98 21 886 304 95; email: info@irta.ir; web: <http://www.irta.ir/conference2009/>

23-28 MAY

2009 ITA World Tunnel Congress Budapest, Hungary

The 35th ITA General Assembly and Congress will be held in Budapest. With a large amount of tunnelling underway and in planning, the organisers are confident it will be a successful event. Contact: Diamond Congress; email: secretariat@wtc2009.org; web: <http://www.wtc2009.org>

07-10 JUNE

Shotcrete for underground support XI Davos, Switzerland

Engineering Conferences International, in conjunction with the ITA, the Swiss Tunnelling Society and several other European Associations is sponsoring the Shotcrete for Underground Support XI. Bringing together specialists from around the world, state-of-the-art of shotcrete methods will be discussed. Contact: ECI; email: info@engconfintl.org; web: <http://www.engconfintl.org/9as.html>

14-17 JUNE

RETC 2009 Las Vegas, Nevada, USA

RETC is recognised as a leading international tunnelling event for contractors and engineers. Last year, conference attendance exceeded 1500 professionals from more than 30 countries and the exhibition sold out in record time. With a venue of Las Vegas, 2009 is sure to be even more of a success. Contact: SME; web: <http://www.retc.org>

17-19 JUNE

Swiss Tunnel Congress '09 Lucern, Switzerland

Held in Lucern, the event spans two days at the city's Culture and Congress Centre and a final day of field excursions. Day 1 features a training conference with TBM tunnelling in soft ground as the topic. Day 2 sees presentations given from local and international tunnelling projects. Contact: Thomi Btäm; email: fgu@thomibraem.ch; web: <http://www.swisstunnel.ch>

22-25 JUNE

5th Symposium of Strait Crossings Trondheim, Norway

Organised by SINTEF and the Norwegian University of Science and Technology, this major symposium aims to act as a forum for the exchange of information, research, new technology and recent experience. The event will also include an exhibition. Contact: NTNU; email: sc09@adm.ntnu.no; web: <http://www.straitcrossings.com>

09-11 SEPTEMBER

IBTTA 77th Annual Meeting Chicago, USA

The International Bridge, Tunnel and Turnpike Association's (IBTTA) 77th Annual Meeting and Exhibition will bring together more than 1000 toll agency professionals for 3 days of networking and innovations in toll industry. Contact: IBTTA; Tel: +1 202 659 4620; web: <http://www.ibtta.org>

13-16 SEPTEMBER

EURO:TUN 2009 Bochum, Germany

The 2nd International Conference on Computational Methods in Tunnelling is organised by the Institute for Structural Mechanics. Contact: Conference Secretariat; Tel: +49 234 32 29051; web: <http://www.eurotun.rub.de>

16-18 SEPTEMBER

Tunnel Construction and Underground Structures, Ljubljana, Slovenia

With an upturn in tunnelling in this region, Slovenia's 9th International Conference on Tunnel Construction and Underground Structures is sponsored by the Slovenian Society for Underground Structures. Contact: SSUS; tel: +386 1470 4617; email: jakob.likar@ntf.uni-lj.si; web: www.drustvo-dpgk.si

08-09 OCTOBER

58th Geomechanics Colloquy 2009 Salzburg, Austria

The popular annual two day event will be held in the Salzburg Congress Centre with session topics including Projects in Austria, Grouting in Rock, Deep Tunnels, and Reuse of tunnel excavated material. Contact: OeGG; email: salzburg@oegg.at; Web: <http://www.oegg.at/events/geomechanics-colloquy>

01-03 DECEMBER

STUVA TAGUNG'09 Hamburg, Germany

Every two years the STUVA conference takes place with various topics from the fields of tunnelling and underground construction. The conferences are attended by approximately 1,500 tunnelling experts from more than 30 different countries. An exhibition accompanies the event. Contact: STUVA; email: info@stuva.de web: <http://www.stuva.de/>

BRITISH TUNNELLING SOCIETY

16 APRIL: **Harding Prize 2009**

Presentations will be given by the three finalists in the biennial competition open to engineers under the age of 33. The winner will be awarded the Harding Prize after the presentations. 6pm start at the ICE

21 MAY: **AGM and A3 Hindhead Tunnel**

Following the Annual General Meeting of the BTS, a presentation will be given by contractor Balfour Beatty on the construction of the UK's longest road tunnel. 6pm start at the ICE

17-19 MARCH 2010

ISTSS 2010 Frankfurt, Germany

The 4th International Symposium on Tunnel Safety and Security. Manuscript abstracts should be submitted to the Secretariat by 01 June 2009, poster abstracts by the 01 October 2009. Contact: Anders Lönnermark, SP Technical Research Institute of Sweden; tel: +46 10 516 56 91; email: anders.lonnermark@sp.se; web: <http://www.sp.se/en/units/fire/news/ISTSS2010/>

14-20 MAY

2010 ITA World Tunnel Congress, Vancouver, Canada

Prior to the 2010 Winter Olympics, the International Tunnelling Association (ITA) visits the spectacular city of Vancouver, British Columbia, for its yearly conference and exhibition. Contact: web: <http://www.wtc2010.org>

8-10 JUNE

InterTunnel 2010 Turin, Italy

Tunnelling exhibition aimed at those involved in building and equipping tunnels. Contact: Mack Brooks Exhibitions; web: <http://www.intertunnel.com>

A DATE TO REMEMBER...

If you know of a tunnelling related conference, event, seminar or exhibition that is not listed here, we would be delighted to hear from you. Please contact the editor by post, email, fax or through our web site: **Tris Thomas, 'Tunnels & Tunnelling International', Progressive House, 2 Maidstone Road, Sidcup, Kent DA14 5HZ, United Kingdom.**
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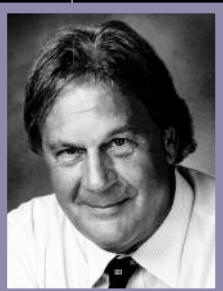
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