Contents

March 2013 No. 15 **ISSN 1031–6760**

AUSTRALIAN TUNNELLING NEWS

NEW ZEALAND TUNNELLING NEWS

ASIAN TUNNELLING NEWS

REST OF THE WORLD TUNNELLING NEWS

SPECIAL FEATURES

DAVID SUGDEN AWARD 2012

AUSTRALIAN/NEW ZEALAND UNDERGROUND MINING NEWS

TECHNICAL FEATURES

HISTORICAL TUNNELLING AND MINING

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New look ATS Website
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Cover photo:
Legacy Tunnel —
Courtesy of TransCity JV

Australasian Tunnelling Society is a Technical Society of Engineers Australia and affiliated with Australasian Institute of Mining and Metallurgy, the Institute of Professional Engineers New Zealand.

The ATS Journal is the official journal of the Australasian Tunnelling Society.

Chairmans Foreword

The last few months have been relatively quiet, especially for suppliers with projects finishing and not a lot to replace them as yet. Tendering is underway for the North West Rail Link in Sydney which is a big enough project to give us all something to look forward to. Waterview in Auckland is slowly happening but it does feel as if it's taken a long time to get going.

A lot of work has gone into our submissions to both the Pike River Enquiry in New Zealand and the Guide for Tunnelling Work here in Australia. Subcommittees were set up in Auckland and Brisbane to ensure that the interests of the tunnelling industry were being considered.

Some of us are starting to plan our attendance at the World Tunnelling Conference to be held in Geneva the first week in June. The Australasian Tunnelling Society put a motion forward at the last General Assembly in Bangkok that the voting method to select the venue for this conference should be changed. We felt that the secret vote allowed delegates to select the venue that best suited their touristic inclinations rather than the venue that provided the most value for the tunnelling industry. We are most interested to hear what the International Tunnelling Society's Executive Committee has to say about our proposal.

We continue to work closely with Engineers Australia towards better governance of Technical Societies and their relationship with EA. There are some major changes underway in EA that will improve communications, administration, financial support, conference support, etc, for the Technical Societies. Both Allan Henderson your secretary and treasurer and I are on EA working groups facilitating this change.

Your local groups work hard to provide an excellent programme of technical sessions, and in order for that to continue they need your support. Talking of support, ask your colleagues at work if they are members of the ATS, if they aren't point out that we are here to provide our industry a voice in determining our future. The larger our membership numbers, the more notice government and the bureaucracy will take of us.

Yours,

Simon Knight, Chairman — ATS

EDITOR'S NOTE

Some special items in this journal — Jurij's award winning paper for the David Sugden Award and some focus articles highlighting tunnelling problems in Japan and New York.

We have also started a FORUM on the website so register and get involved.

David Lees, ATS Editor

Join the ATS Forum

New on the ATS website is a forum to allow members to discuss issues of importance or to seek advice from experts within the industry.

It's free to join – just register on the page

http://www.ats.org.au/index.php/forum/welcome-mat/2-welcome-to-the-new-ats-forum

THE DAVID SUGDEN YOUNG ENGINEERS WRITING AWARD 2013

SPONSORED BY ATS

Win a chance to attend the 2014 ITA World Tunnel Congress in Iguassu Falls, Brazil

- The competition is open to all ATS Members and University Students under 35 years of age (as at 31 August 2013)
- The task is to write a technical paper on any subject related to tunnelling and underground construction — not less than 2,000 words and not more than 5,000 words.
- Best paper to be judged by the ATS Executive Committee.
- Closing date **30th June 2013**
- Winner announced by 31 August, 2013
- The prize includes complimentary conference registration fees and $2,000 towards personal travel and accommodation costs at the ITA World Tunnel Congress to be held in Iguassu Falls, Brazil from 9–14 May 2014.

The winner may also be asked to be part of the ATS National Committee as the Young Engineers Representative.

For more information contact Stephanie McMullen
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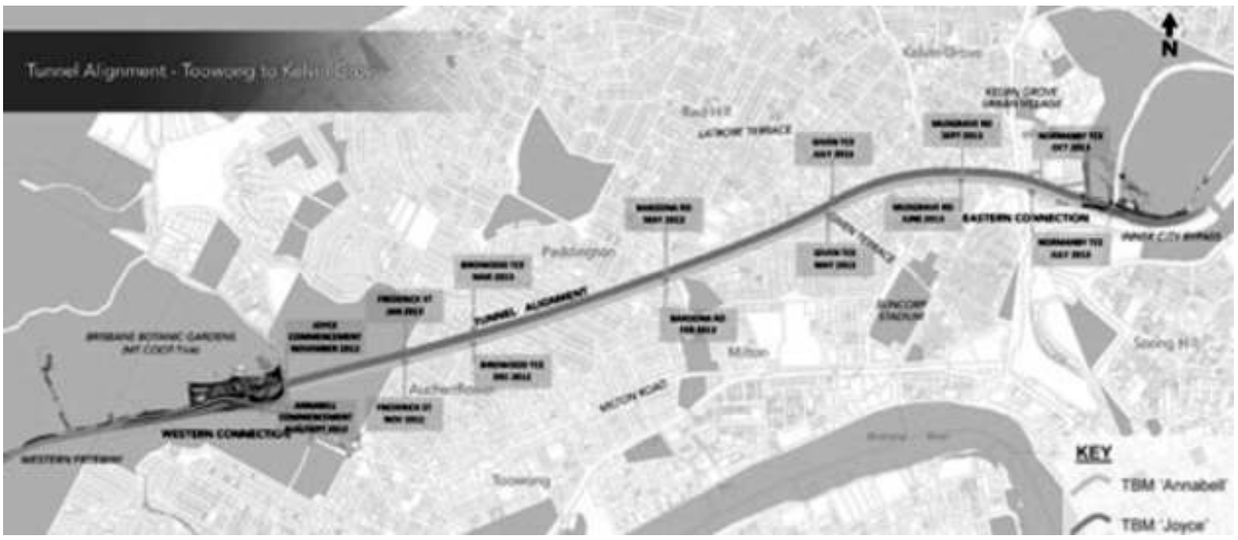


Legacy Way on track

Legacy Way is the 4.6 kilometre road tunnel that will connect the Western Freeway at Toowong with the Inner City Bypass at Kelvin Grove.

Legacy Way is Brisbane City Council's largest road infrastructure project, with $500 million in funding coming from the federal government's nation building program. Federal Infrastructure and Transport Minister Anthony Albanese said after several years of detailed planning, extensive community consultations and preconstruction activities, it was great to see this important project well under way. "We recognise that the task of modernising and expanding the city's road, rail and public transport infrastructure is too big for any one level of government," he said. "That's why we have partnered with Brisbane City Council on the Legacy Way project, and we are determined to get the job done."

Construction started in 2011 and the TBMs were delivered to site in May 2012.

Annabell and Joyce make light work of tunnelling

Legacy Way is celebrating the outstanding progress made by the project's tunnel boring machines (TBMs), *Annabell* and Joyce, as they excavate the tunnels at record speed. Together, both TBMs continue to exceed expectations and are averaging excavation at a rate of more than 150 metres per week, which sets the project at a world class standard for production.

Annabell has excavated more than 2 kilometres since excavation began on the project in late August and tunnelled 48 metres on the TBMs best day.

Joyce has also passed the 2 kilometre mark and has exceeded expectations thanks to lessons learnt from *Annabell's* tunnelling activity to date. *Joyce* holds the staggering record of excavating 49.7 metres in one day, as well as a maximum of 248.8 metres in one week and a 30 day maximum of 787.8 metres.

Tunnelling is now nearing the halfway mark, with both TBMs expected to complete their journey from Toowong to Kevin Grove in mid-2013.

First tunnel cross passage excavated

Legacy Way will be connected by 36 underground cross passages, located every 120 metres along the tunnel

alignment. Measuring 4 metres wide by 3.5 metres high and 10 metres long, these passages will provide tunnel users with a safe passage from one tunnel to the other in the unlikely event of an incident.

In December 2012, Transcity successfully constructed the first cross passage under the Toowong Cemetery in Toowong. The second cross passage was excavated under Auchenflower in January 2013.

A further cross passage is being built between January and March 2013 to allow workers to exit safely in the event of an emergency during tunnel construction. The tunnel boring machines will cease operation during excavation of this cross passage for safety reasons and to alleviate traffic and workforce congestion within the tunnel. Cross passage excavation will be carried out 24 hours a day, seven days a week.

The remaining 33 cross passages will be excavated later in 2013 once tunnelling is completed, with each cross passage expected to take approximately 10 to 12 days to complete.

Spoil removal

The spoil excavated travels by conveyor from each TBM, exiting at the western tunnel portals to a transfer station located within the western worksite. From the transfer station a single conveyor transports the material via a specially constructed 500 metre long conveyor tunnel to Mt Coot-tha Quarry.

Brisbane City Council's proposed sale of tolling rights

The Brisbane City Council has proposed selling the tolling rights of the Go Between Bridge and Legacy Way Tunnel to the Queensland Investment Corporation.

The yet-to-be-finalised deal would see the state-backed Queensland Investment Corporation and Queensland Motorways taking over tolling rights for the tunnel and the Go Between Bridge. Lord mayor Graham Quirk said negotiations are under way to hand over operational control of the $1.5 billion tunnel and $308 million bridge, most likely under a 50-year lease.

The deal would leave BCC at least partially shielded from hundreds of millions of dollars in losses, which the tunnel alone is expected to generate during its initial years of operation.

The new operators would also take on the costs such as road maintenance and repairs, reducing council's expenses.

Council's $1 billion investment in Legacy Way as well as ratepayers' ongoing financial exposure to the project, have previously raised concerns particularly in light of the underwhelming performances of the Clem7 and Airport Link tunnels.

But Cr Quirk denied the possible deal was a relief and said he remained "very positive about Legacy Way", although based on current council forecasts Legacy Way is not expected to be economically viable until the 2026–27 financial year, while the Go Between Bridge will not be viable until 2030–31.

Airport Link design team wins Bentley award

The team responsible for the design of the Brisbane Airport Link projects — the Parsons Brinckerhoff and Arup Joint Venture (PBAJV) — has received the Special Recognition Award for Sustaining our Society at the Bentley 2012 Be Inspired Awards on 14 November in Amsterdam.

Regarded as the highest honour of the awards program, the Special Recognition Award recognises outstanding achievement in infrastructure — representing the 'best of the best' and chosen from a competitive field of entries from across the world.

PBAJV was a finalist in the individual award categories of *Innovation in Roads and Connecting Project Teams* for its entry for the Airport Link, Northern Busway (Windsor to Kedron) and Airport Roundabout Upgrade projects. Only projects that reach the finalist designation for each category were eligible for a special recognition award.

A project of such significant scale and complexity — at $5.6 billion, it is one of the largest road and transport infrastructure projects in Australia's history — required a truly collaborative effort to deliver 1,500 separate design packages and more than 35,000 design drawings. Over 1,000 PBAJV team members worked more than one million hours to design this project and provide construction phase support, drawing on their extensive local and international skills and resources. Specialist design professionals were mobilised from around the world to form what became a highly effective delivery team.

Bentley solutions that were used for the design include: (MicroStation, MXROAD, InRoads, Structural Modeler, and gINT) and project collaboration document control (ProjectWise).

PBAJV Project Director Luke van Heuzen (Parsons Brinckerhoff) and Technical Director Marty Scrogings (Arup) collected the award on behalf of the joint venture at the official ceremony.

"It is a tremendous honour for the PBA team to receive the special recognition award for our work on this complex piece of infrastructure. We thank Bentley for its ongoing support to us throughout the project, and also congratulate all the other finalists and award winners this year.

The entire project team is very proud of our involvement in this project which delivers a social legacy for Brisbane. The design brief challenged us to collaborate intensively to produce technically excellent solutions that are world class on every possible measure. The sheer size of the Airport Link projects bring with it a huge engineering challenge in terms of coordination and management of the design teams, the number of drawings to be produced, and best practice data management.

As a collaborative tool, Bentley ProjectWise enabled us to meet the project's challenging design brief, ultimately helping the PBA team and our construction partners Thiess John Holland to redefine the urban fabric of our city through an innovative and inspired design."

Luke van Heuzen, PBAJV Project Director

Computer switch blamed for City Link tunnel closures

Transurban says a faulty network switch was to blame for the closure of Melbourne's Burnley and Domain tunnels in October 2012. The tunnels were shut down for more than 12 hours causing traffic chaos around the city. The computer failure meant that Transurban could not broadcast speed limits or warnings to motorists. A back-up system was also overwhelmed.

Transurban's chief executive Scott Charlton says an investigation has found the tunnels' computer systems were overloaded by a flood of mistakenly-generated error messages. He says CityLink could not open any lanes in the tunnels because the sprinkler and smoke extraction systems were not working. "We have operated this system for quite some time and in the past where we've had network switch issues, the back-ups have always performed according to the design," he said. "We have made changes and have put some operations in place to deal with the issue so that it won't happen in the future." Transurban says there is no evidence of hacking and it has upgraded its systems.

Airport Link poor traffic forecast

Less than four months after the opening of the tunnel, BrisConnections announced it had entered "formal negotiations with lenders and other key stakeholders" to discuss their options.

"Taking into account ... present traffic levels and operating costs, the enterprise value may be less than outstanding debt," read a statement posted on the Australian Stock Exchange. "As previously advised, BrisConnections is reviewing cost and revenue options and has retained advisers to undertake a review of likely traffic levels in the light of current information." The tunnel will remain open to motorists despite the financial crisis.

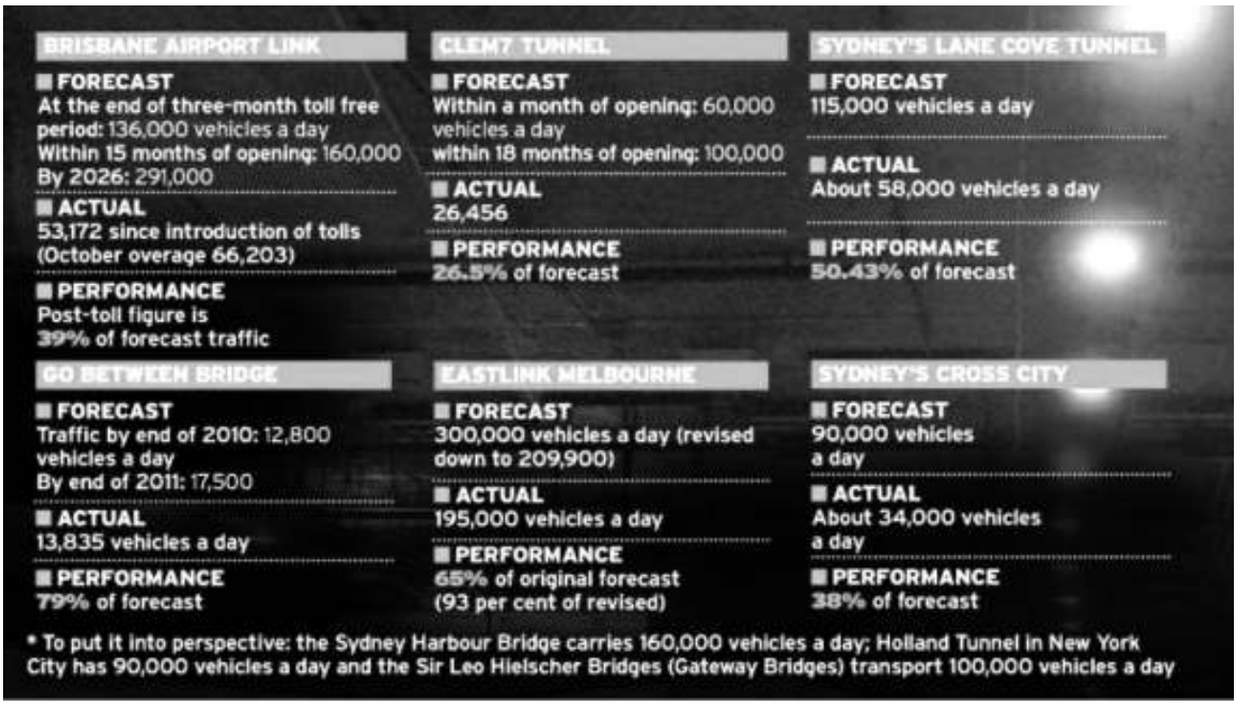
BrisConnections initially forecast Airport Link would carry 136,000 vehicles a day by the end of the three-month, toll-free period. Instead, traffic volumes plunged to an average 53,172 vehicles a day when a discounted toll of $2.50 was applied from 18 October 2012. The rapid downfall of the project follows the failure of Rivercity Motorway's Clem7 Tunnel which went into receivership 10 months after opening with debts of $1.3 billion.

Despite the toll road failures, Brisbane City Council is pressing ahead with the $1.7 billion Legacy Way due to open in early 2015.

Forecast to carry annual operating losses of almost $100 million, the project is largely funded by ratepayers with the Federal Government contributing $500 million. Lord Mayor Graham Quirk said he was confident about the traffic forecasts for Legacy Way which were much more conservative than those prepared for Airport Link and the Clem7.

"(We're forecasting) about 24,000 vehicles a day on opening in 2015," Cr Quirk said. "While (BrisConnections') traffic forecasts were ambitious, there were about 65,000 vehicles a day during October using Airport Link to help reduce traffic congestion across the city and the infrastructure will be there for many, many decades to come."

Paul Turner from peak motoring body RACQ said the tunnels were a positive addition to northside Brisbane's road network. "We've now got considerably less traffic on surface roads, and one of the best runs from the northside to the airport," Mr Turner said. Since opening in late July, Airport Link has had a dramatic effect on surface roads including Lutwyche, Albion and Sandgate roads.



Comparison of forecast and actual tunnel traffic of major tunnel projects in Brisbane, Sydney and Melbourne. Source: The Courier-Mail.

Concerns for workers attending accidents in the CityLink tunnels

Workers attending accidents in the CityLink tunnels are being exposed to "extreme" levels of cancer-causing diesel fumes, and a risk assessment by TransLink warns that workers could develop cancer over 15 years.

The documents show workers were breathing in "extreme" levels of diesel particles and that there was a high likelihood they could contract cancer.

The Domain and Burnley tunnels opened in June 1999, raising fears that some workers could be close to showing signs of illness. But CityLink and the RACV have rejected

the report, saying that the tunnels met WorkSafe standards.

The Australian Manufacturing Workers Union has demanded new full-face breathing apparatus, similar to what firefighters use, for staff clearing accidents.

NSW Government commits to WestConnex

A report by Infrastructure NSW, released in October 2012, included 70 recommendations on transport, health, education, energy, water and the arts.

But the NSW government has only committed to the strategy's highest priority project, the $10 billion WestConnex motorway from Auburn to Sydney Airport. The scheme includes several underground sections including:

- Duplication of the M5 East tunnels,
- A tunnel from Taverners Hill to the St Peters area via the Camperdown area.
- An M4 Extension connecting the existing M4 at North Strathfield to Taverners Hill in Petersham. The M4 Extension could be constructed with various sections in tunnel, cutting ("slot"), at grade or on elevated road so as to optimise urban renewal along Parramatta Road.

Mr O'Farrell said cabinet had agreed to reserve $1.8 billion from its infrastructure fund towards the WestConnex project.

Mr O'Farrell said the WestConnex project would be overseen by a new motorway project office within the Department of Roads and Maritime Services.

The office will have the task of ''making WestConnex a reality'', he said and producing final details of how it should be funded, including the shape of the public-private partnership, the tolling regime and a timetable for construction phases.

The Treasurer, Mike Baird, challenged the federal government to match the $1.5 billion funding commitment to the WestConnex motorway by the federal Opposition Leader, Tony Abbott.

He said Infrastructure NSW would put forward a funding submission for WestConnex to its federal counterpart, Infrastructure Australia.

''We ask the Prime Minister to come forward and endorse it and get on with the job of supporting a critical project for the future of this State,'' he said.

Mr Baird said any money the federal government put towards the project ''provides the capacity'' to have lower tolls and bring the completion date forward from its estimate of 2022.

Another high profile priority project identified by Infrastructure NSW is construction of a tunnel between the F3 to M2 motorways under Pennant Hills Road.

The project, which was an unsolicited proposal by the private company, Transurban, is listed as one that should be commenced within the next five years.

Mr O'Farrell said that ''no decision has yet been made'' on the project which was ''currently being assessed''.

Lane Cove Tunnel emissions not a health issue

A three-year study by the Woolcock Institute of Medical Research has found Lane Cove Tunnel has had minimal impact on the respiratory health of residents living around the tunnel since its 2007 opening.

About 3000 residents completed a survey in 2006, before the tunnel opened, and again in 2007 and 2008, after it opened. Some 380 residents also recorded their symptoms and measured their lung function twice a day for two months each year. Air pollution was measured at more than 40 sites near the tunnel.

The study found that the tunnel halved Epping Rd traffic at Lane Cove and improved air quality, but did not lead to any notable change in the respiratory health of adjacent residents. Residents near the eastern ventilation stack, however, reported more respiratory problems in both years after the opening. They also had slightly lower lung function in the first year, but not in 2008. The study concluded that this was not because of the tunnel, as pollution near the ventilation stack did not increase.

Professor Guy Marks, who led the study, said it was important to note at a time when proposals were being considered for major new roads. "In this study the redistribution of road traffic by means of a tunnel had little impact, good or bad, on the respiratory health of residents in the surrounding area," he said. Professor Marks, however, said the traffic changes did lead to lowered concentrations of nitrogen dioxide, a common marker of traffic-related air pollution along Epping Rd.

M5 East Filtration Plant to close

The $76 million M5 East tunnel plant to filter air pollution will be closed, after the State government said it was not worth the money. The Roads Minister, Duncan Gay, said the study had found the plant, installed in 2010, had made little impact.

The plant was installed following widespread community concerns about unacceptable smog levels in the tunnel, which opened in 2001. Instead the government will spend $8.5 million over three years on other air-quality programs, including retro-fitting old trucks with cleaner exhaust systems. "The study indicated about 5 per cent of total haze pollution and 3 per cent of nitrogen dioxide in the tunnel was being removed via the filtration plant," Mr Gay said. "While these results are not what we expected, motorists should be aware the levels of pollution within the tunnel have been monitored 24 hours a day and have not exceeded World Health Organisation standards," he said.

Mr Gay said Roads and Maritime Services would encourage owners of older trucks to come forward. Their vehicles might then be fitted with a particle trap, with the State government paying 50 per cent of the costs. Fines for old trucks spewing excessive exhaust would also be increased.

HISTORY OF THE ATS

The Australasian Tunnelling Society is an Engineers Australia Technical Society which has had an interesting evolution within the organisation. A brief history on the formation of the ATS follows:

In 1972 the Australian Geomechanics Society (AGS) created the National Tunnelling Committee following a proposal from the Department of National Development in 1971 in response to an official OECD report which included a recommendation that individual countries should set up a national tunnelling agency to define and promote areas of research and development in this technology.

The National Tunnelling Committee later became the Australian Tunnelling Association, then the Australian Underground Construction and Tunnelling Association and is now the Australasian Tunnelling Society (ATS).

The creation of the National Tunnelling Committee by the AGS was approved by Engineers Australia and the Australasian Society of Mining and Metallurgy. In June 2006, Engineers Australia entered into a Heads of Agreement with the Institution of Professional Engineers New Zealand (IPENZ) to "facilitate the formation of a Joint Technical Society known as the Australasian Tunnelling Society".

MELBOURNE MAIN SEWER REPLACEMENT

Melbourne's new sewer main was officially commissioned in an event held on 18 June 2012. The project was delivered on time and $A14 million under its $A220 million budget. The Melbourne Main Sewer Replacement (MMSR) involved the construction of approximately 2.3 kilometres of new sewer mains in and around inner-city Melbourne. The new sewer has three times the capacity of the original sewer and will service the CBD and the fast-growing Docklands precinct, which is expected to be home to 20,000 residents and a workplace for 25,000 in 15–20 years' time. Delivered ahead of schedule, the project included a 140 metre on-grade crossing of Melbourne's Yarra River, and trenchless construction of 1.9 kilometres of smaller branch and reticulation sewers to connect houses and businesses to the new main.

The MMSR was one of the most challenging soft-ground tunnelling projects undertaken in Australia. The new sewer tunnels were excavated in difficult geology, under water, beneath a city and through densely populated suburbs. Geological challenges involved overcoming variable ground conditions, including Fishermans Bend silt, Coode Island silt and Port Melbourne sands, combined with a high watertable. The presence of hard basalt rock in areas along the new tunnel alignment made geological assessment and planning paramount.

Six large-scale vertical access shaft sites were constructed along the new sewer route. Most work took place up to 15 metres below ground, using a state-of-the art earth pressure balance (EPB) tunnel boring machine (TBM). Working with TBM manufacturer, Caterpillar, the project team custom modified the 103 metre, 164 tonne TBM to ensure it could provide stability and alignment control through soft, weak soils and navigate a number of tight, 250 metre radius curves, while delivering enough torque and power to break through high strength weathered basalt rock.

Numerous field trials, steering theories and design simulations were undertaken. The rigorous modelling and construction solutions accurately addressed the geology of the tunnel drive and, as a result, tunnelling works were completed in 18 months.

The project tunnelled under some of Melbourne's most valued land, including playgrounds and public reserves. Works came within metres of major infrastructure and developments, including the South Wharf retail outlet, Melbourne Convention Centre, and M1 and Westgate Freeways. Six years of planning gave MMSR a solid foundation. A critical project decision was to involve the construction contractor and key stakeholders early in the design phase. This collaboration resulted in the redirection of the main tunnel route to run under public land in Port Melbourne, avoiding excavation directly under houses.

The team worked closely with residents, businesses and community organisations to co-ordinate project activities. Tunnelling operations were limited to daylight hours (7am to 6pm) to minimise the impact on surrounding communities.

The project encompassed the construction of 1.9 kilometres of branch and reticulation sewers to connect local houses and businesses into the new main. Trenchless Technology was utilised to complete this intricate set of works. Small diameter microtunnelling machines were used to pipe jack 300-600 millimetre clay vitreous pipes. Low-profile caisson shafts enabled sites to operate safely and efficiently within the constraints of narrow one-way streets.

The project was one of the first in Australia to use steel-reinforced concrete segments for the primary liner, followed by a secondary corrosion-resistant liner of glassfibre-reinforced plastic (GRP), rather than a conventional, sacrificial concrete liner as a barrier against the corrosive sewage environment. This design is expected to deliver a 100-year-plus life. Lining the main tunnel involved installing 580 sections of 1.8 metre diameter GRP pipes in 3 and 6 metre lengths.

The GRP pipes were installed using a hydraulic pipe-carrier specifically designed for the project. The use of adjustable spud jacks allowed for the final installed GRP liner to be finished as close as possible to the design grade.

GRP pipes have fewer joints per tunnel length than conventionally lined tunnels and an impermeable cross-section, which virtually eliminates groundwater ingress. The smoother surface is also easier to maintain than traditional concrete lined sewers.

The project's major environmental and social challenge was constructing a 140 metre section of sewer under the Yarra River.

A deeper than anticipated riverbed raised significant risks to safety, ground and river water quality and flow, as well as the potential for a TBM to sink into the low-strength alluvium and silty clay. Investigations confirmed an alternative to conventional tunnelling was needed. A staged wet cofferdam was proposed. This novel approach saw specialist divers work in zero visibility conditions within the wet cofferdam. Each cofferdam was constructed using steel sheets to create a 6 metre wide, enclosed rectangular box divided into two cells: one for construction, the other to temporarily store excavated material. Inside the cofferdam, the riverbed was excavated to allow the sewer to be laid and then backfilled to the original riverbed level. The river crossing was completed in three stages over two years, allowing the river to remain open to commercial and recreational traffic.

The Melbourne Main Sewer Replacement was awarded the ASTT Installation Project of the Year Award for 2012.

Trucks stuck in M5 East

Truckies who ignore height warnings have been verbally spanked by Roads Minister Duncan Gay after a second truck became stuck in a tunnel in as many weeks in November 2012. An overheight truck drove down the M5 East tunnel, smashing traffic signs — including one that warned of height restrictions. The mishap caused extensive damage and closed city-bound lanes for almost 12 hours. It was the second such incident on the M5 after another truck became wedged on the Marsh St on-ramp.

Mr Gay said he could not understand the "unbelievable" actions of some drivers.

In the latest incident, the truckie entered the tunnel, crashing through an overheight warning barrier before hitting overhead traffic signs on the way. He also caused damage to the tunnel's roof. The truck was eventually stopped at Mascot, and the driver is now facing major penalties and demerit points.

This problem is not limited to Australian tunnels with recent incidents reported in Alabama and London.

Pipe jacking under the Scenic Rim

Queensland Urban Utilities has completed over $A2 million worth of water and wastewater infrastructure upgrades in the Scenic Rim region.

In Boonah, approximately 40 kilometres west of Beaudesert, pipe jacking was used to complete the $A700,000 Hoya Road Sewer Upgrade Project, which involved replacing 445 metres of rising sewer main and installing 880 metres of new gravity sewer main.

A 30 metre long DN200 millimetre pipe was used to jack under Hoya Road b y contractor Tunnel Boring Australia.

Also part of the Scenic Rim upgrades was the $A1.2 million William Street Watermain Upgrade Project.

Pezzimenti microtunnelling in Hobart and Adelaide

Hobart

Pezzimenti Trenchless was recently awarded a bore in Salamanca Place, Hobart, for Water Industry Solutions and Southern Water. The job involved a 36 metre bore under Salamanca Place, Hobart's oldest and most important tourist and cultural region.

A 225 millimetre PVC pipe was installed as part of the Salamanca Place pump station relocation works.

Ground conditions encountered were Jurassic Dolerite, a volcanic basalt type rock that covers over a third of Tasmania.

"They were probably the hardest rock conditions that we have taken on, but we still averaged 12 metres per day using our 440 millimetre diameter basalt microtunnelling head," said Pezzimenti Trenchless Director Joe Pezzimenti.

Mr Pezzimenti said the company looks forward to taking on the challenge of projects in Tasmania in the future.

Adelaide

Pezzimenti was awarded a boring contract in South Australia for Camco Engineering and Construction and the City of West Torrens. The bore involved pipe jacking an 800 millimetre Humes Jacking Pipe under one of Adelaide's busiest thoroughfares, South Road, Mile End. To perform the installation in this highly sensitive area, the company utilised its 1,050 millimetre microtunnelling head.

The 30 metre length bore was completed within the same week of arriving on site. "We see some huge potential with our microtunnelling system in South Australia, and look forward to working with authorities and contractors in the future," said Mr Pezzimenti.

Brisbane microtunnelling project complete

UEA Trenchless recently completed a 110 metre 450 millimetre diameter bore using pilot tube microtunnelling methods beneath the Bruce Highway at Dakabin, 26 km north of Brisbane.

The pipe alignment, undertaken on behalf of Unitywater, went under the Bruce Highway and an adjacent creek. UEA Trenchless previously undertook a horizontal investigative bore that was completed successfully, confirming ground conditions as clay and decomposed sandstone.

UEA Trenchless used a guided boring machine (GBM) to place pilot tubes along the centre of the alignment. The pilot tubes were followed by a 450 millimetre diameter auger bore, which placed a steel case ready to envelop the DN350 polycrete product pipe.

The accuracy of the pilot bore allowed the insertion of a comparatively small diameter enveloper, which allowed a 30 millimetre annulus to the product pipe. UEA said that a traditional steering method would have required a 600 millimetre diameter enveloper at minimum to allow for vertical inaccuracies. The product pipe was inserted and grouted into position marking the completion of the pipe installation.

UEA said it had partnered with CLM Infrastructure to deliver a solution for inserting small diameter pipe on very flat grades over long distances.

PIPE JACKING IN THE WEST

A ground breaking project for HOBAS pipe in Western Australia's Pilbara Region

The Pilbara Region is located in the North Western corner of Australia in what is known as one of the hottest and at times wettest parts of the world. The Pilbara Region was first inhabited by the ancestors of today's Indigenous Australians some 40-50,000 years ago. In the 1950s, it was discovered that the Pilbara area was home to one of the world's largest iron ore deposits. Since this time the region has been an integral contributor to the Australian economy with the help of mining companies such as Rio Tinto.

Upgrading the Cape

Today, the Pilbara region is home to the rail and port infrastructure needed to transport ore from this remote region. With most of the ore being exported, large ports have been built to accommodate the ore transport; one of the largest of these ports is Rio Tinto's Cape Lambert. Trains travel in from Rio Tinto mines throughout the region, carrying around 80 million tonnes of iron ore per year into Cape Lambert for processing and ship loading.

At present, the port is undergoing an infrastructure upgrade that will see the transportation capacity of Cape Lambert port more than double by mid-2015. Included in the infrastructure upgrades are additional rail lines, ore dumpers, stockyards and jetty. At the project completion, an estimated 200 million tonnes of iron ore will be exported per year from this port alone.

Trenchless installation: the obvious choice

An integral part of the of the overall upgrade are the 'Sam's Creek' stormwater drainage lines, which run under the existing rail lines and allow the release of stormwater during the wet season. Any upgrades to these drainage lines needs to allow the existing rail lines above to stay in constant operation to maintain continual loading of ships. The rail lines are a critical piece of the mining infrastructure and stopping the productivity across this rail for drainage upgrades was not an option, making trenchless installation the only choice. The design of the new drainage culvert specified two rows of 2,100 millimetre internal diameter pipes at approximately 100 metres long, each with an additional row of 2,100 millimetre internal diameter pipes for services.

Sinclair Knight Merz (SKM), who were contracted to design and manage the project, finalised the upgrade plans specifying HOBAS jacking pipe with an outside diameter of 2,250 mm. The top of the culvert sits approximately 3 m below the rail line, being installed in hard rocky ground. Pipes with a stiffness of SN32,000 were chosen by SKM, given the initial calculations expected a jacking force of up to 800 tonnes would be applied. Intermediate jacking station pipes were also supplied.

HOBAS reduces risk and installation time

With the rocky ground conditions, the smooth outer surface of the HOBAS pipes, coupled with the use of bentonite and the much smaller outside diameter of HOBAS jacking pipe, resulted in a significant reduction in the expected jacking forces required to jack the pipes, compared to the alternative option of using concrete pipe. The substantially smaller outside diameter had the additional benefit of allowing increased ground cover beneath the rail line, reducing both risk and installation time.

Both the client and contractor were surprised to learn that the lead-time for HOBAS was substantially shorter than that of locally supplied concrete pipe. Given the tight timeframe for the project, the decision to use HOBAS was easy. Credit must be afforded to SKM, NRW-NYFL and Tunnel Boring Australia for adopting worldwide proven technology to ensure their project is completed with minimal risk, quickest installation time and most cost effective pipe option.

NRW-NYFL Joint Venture is the head contractor for the works and with the guidance of SKM they have employed Tunnel Boring Australia to undertake the installation of the Sam's Creek culvert. This installation will set new records in terms of the largest diameter HOBAS jacking pipe installed in Australia, paving the way for similar projects in the ever growing mining industry in Australia.

Promoting awareness of traditional land owners

The NRW-NYFL Joint Venture was established to promote understanding and cultural awareness of the traditional owners of Cape Lambert, as well as to develop employment opportunities within the project for local indigenous workers. The joint venture had the ground breaking idea to use this fascinating project as an opportunity for cultural awareness. The joint venture partner Ngarluma Yindjibarndi Foundation Limited (NYFL) invited local artists Loreen Samson, Katherine Samson, Pansy Hicks and Wendy Warrie to paint the HOBAS pipes in the artistic style of the traditional owners. The images bring good fortune to the land and the HOBAS pipes are now truly part of the local landscape.

Key North West Rail Link Milestones reached

February 2013 saw Minister for Transport, Gladys Berejiklian announce that Sydney's North West Rail Link was another step closer with two key milestones reached.

Tenders to build the billion-dollar tunnels had closed, and expressions of interest on a separate contract to operate the rail link had also closed.

"I'm really pleased to announce these milestones — we are getting on with the job of building the North West Rail Link," Ms Berejiklian said.

"We are on track to have tunnel boring machines in the ground next year, which is exciting not just for the north west, but the whole of NSW."

Three tenders were received to build the 15 kilometre twin tunnels between Bella Vista and Epping — the longest rail tunnels ever built in Australia.

The tenders for the Tunnel and Station Civils (TSC) contract, to be assessed over coming months, were from:

- Baulderstone Bouygues Travaux Publics Joint Venture;
- Rapidlink Joint Venture — Obayashi, McConnell Dowell, Laing O'Rourke Australia
- Thiess John Holland Dragados Joint Venture.

This contract, fully funded by the NSW Government, is expected to be awarded around the middle of this year. The Operations, Trains and Systems (OTS) contract includes supplying Sydney's new-generation single deck trains and converting the Epping to Chatswood Rail Line. Three consortiums made up of a combined 17 organisations from Australia and overseas have lodged expressions of interest for the contract. They are:

- Northwest Rapid Transit MTR Corporation (Australia), John Holland, Leighton Contractors, UGL Rail Services, Plenary Group;
- TransForm — Serco Australia, Bombardier Transportation Australia, SNC-Lavalin Capital, McConnell Dowell Constructors (Aust), John Laing Investments, Macquarie Capital Group; and
- The Pulse Consortium — Keolis Australia, Downer EDI, Obrascon Huarte Lain, Ansaldo STS Australia, Mitsubishi Corporation, Bank of Tokyo-Mitsubishi UFJ.

"This is a massive vote of confidence in the North West Rail Link and the NSW Government's rapid transit system," Ms Berejiklian said. The submissions will now be evaluated and shortlisted as the contract moves forward to the request for proposal stage. The contract will be delivered as a public private partnership subject to being value for money for taxpayers. "It's full steam ahead on the North West Rail Link — we're getting on with the job of delivering a fast, safe and reliable rail system to the people of the north west for the very first time," Ms Berejiklian said.

NWRL PROJECT FAST FACTS

- Eight new stations will be built at Cherrybrook, Castle Hill, Showground, Norwest, Bella Vista, Kellyville, Rouse Hill and Cudgegong Road;
- Total of 4,000 commuter car spaces are also part of the project — making up about 10 per cent of all commuter car parking on the entire Sydney rail network;
- Includes fast, safe and reliable new generation single deck trains;
- Twin tunnels will be 15.5 kilometres long, and each tunnel boring machine will weigh about 1000 tonnes.
- Some tunnel boring machines can to 200 metres long and can cut 120 metres of tunnel a week.
- Three major contracts are part of delivering the North West Rail Link:
- Tunnel and Station Civils (TSC) contract to build the twin 15 kilometre tunnels and underground station excavation — expected to be awarded middle of this year (fully funded by the NSW Government);
- Surface and Viaduct Civil (SVC) contract to build the 4 kilometre skytrain and associated civil works including embankments and cuttings for the railway — three groups have lodged expressions of interest, with tenders to be called in coming months (also fully funded by the NSW Government); and
- Operations, Trains and Systems (OTS) contract to deliver the new-generation single deck trains, install tracks and signalling and operate the North West Rail Link — a Public Private Partnership to be awarded in 2014.

Melbourne oldest sewer network upgrade

Melbourne Water is preparing to replace a 2.7 kilometre section of one of Melbourne's oldest sewer networks with works starting in late 2013. The original brick-lined sewer, which services 85,000 properties, is in a poor condition after nearly a century of use.

The new sewer will be built at depths of up to 21 metres underground from Coate Park in Alphington to the Latrobe Golf Course. It will connect to another section of sewer main being built near the Eastern Freeway in Kew that crosses the Yarra River into Alphington. While the original sewer was dug by hand, its replacement will be built using a tunnel boring machine and open trenching.

Melbourne Water project spokesperson Phil Corluka said Melbourne Water would be drawing on the lessons learnt in similar projects to deliver the works. "We recently finished a major sewer project that involved tunnelling under parts of the CBD and Docklands," Mr Corluka said. "We learnt a lot from this project and will be drawing on these experiences to ensure the works run smoothly and with the least impact on residents and businesses.

Northbridge Tunnel upgrade

The Northbridge Tunnel in Perth was closed for four nights in October 2012 for a system upgrade. A Main Roads WA spokesman said the works involved the replacement of the tunnel's remote control unit (RCU), which controls the tunnel's ventilation fans, fire systems, electronic signs and other features, with a more modern system.

He said the works were not associated with the planned tunnel two-to-three-lane upgrade project, but needed to be done before the project could begin. "The upgrade works will ensure that road users are provided with the highest quality road infrastructure and reliable tunnel operation," the spokesman said.

Shunting vehicle

A mobile "shunting machine" will patrol the Graham Farmer Freeway tunnel in an effort to reduce congestion caused by accidents.

Mr Buswell said the new Incident Response Service (IRS) for the Northbridge tunnel would operate in a similar way to those used elsewhere in Australia.

This service will help clear vehicles involved in crashes or breakdowns in the tunnel and relocate them to a safe area. Work crews will patrol the Graham Farmer Freeway between Loftus Street and the Swan River, responding to incidents that affect traffic flows from Monday to Friday between 6am-6pm. The idea is to make sure traffic flows can be returned to normal as quickly as possible to reduce congestion during peak times.

The front of the IRS vehicle has a soft foam "push pad", which shapes itself to the design of the affected car before moving it to a safe location away from traffic. Road users who have their vehicles relocated will be advised by the IRS operator as to what they need to do to successfully move their car.

The IRS is part of "Active Traffic Management" identified in the Perth Central Business District (CBD) Transport Plan — a State Government initiative to improve congestion management on Perth city roads and the freeways. Active Traffic Management will allow Main Roads to play a more active role in keeping traffic in the tunnel moving as efficiently as possible.

Laverton Creek Drainage Scheme

Trenchless Civil is constructing a major floodway for Melbourne Water as part of the Laverton Creek Drainage Scheme. This includes pipe jacking seven DN1,650 millimetre concrete pipe culverts under the Melbourne–Ballarat rail corridor, operated by V/Line. Each culvert is 50 metres in length, running parallel within 1 metre of each other. The depth to pipe crown below the railway is approximately 5 metres.

The geology consists mainly of high strength to extremely high-strength basalt with occasional gravel and clay bands, requiring a tunnel boring machine (TBM) with closed face capacity. Trenchless Civil is utilising its MTS slurry TBM with earth pressure balance (EPB) capability, with the addition of a rock cutterhead that has been manufactured specifically to suit the anticipated geology. The system is proving highly successful with average advance rates of over 30 millimetres per minute achieved. Cutter wear has also been limited with cutter changes occurring after every second tunnel drive.

Trenchless Civil has liaised closely with V/Line throughout the project. The rail corridor being worked under enables high speed transport between two major Victorian centres, and therefore it is vital this service is not disrupted. As an added precaution, pipe jacking under the rail lines has been undertaken outside train operating hours. Stringent survey monitoring has confirmed no settlement of the tracks has occurred due to the tunnelling operation.

The successful running of the project has enabled each bore to be completed within a week and the tunnelling component of this project was completed in early December 2012. Remaining works to construct concrete headwalls and finish floodway excavation are due for completion in April 2013.

Microtunnelling under the Camden Valley Way

Sydney Water has completed an $A5 million project that utilised microtunnelling to install water and wastewater infrastructure to over 2,000 new homes in Edmondson Park.

Sydney Water Managing Director Kevin Young said Sydney Water's NetWorks Alliance partnership, comprising Lend Lease, Veolia Water Network Services and CL M Infrastructure, undertook the work, which involved installing approximately 400 metres of water pipeline and 1.6 killometres of wastewater pipeline.

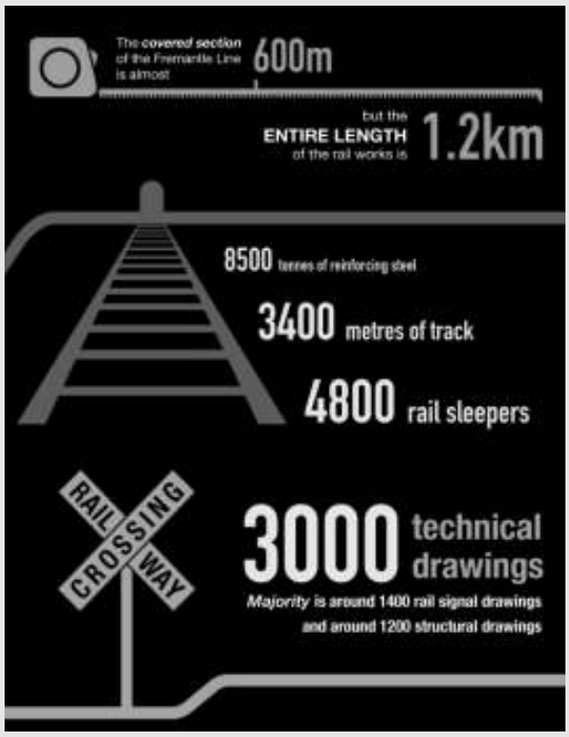
A spokesperson on behalf of Sydney Water said NetWorks Alliance microtunnelled approximately 30 metres under the Camden Valley Way and in another location for sewer for approximately 300 metres.

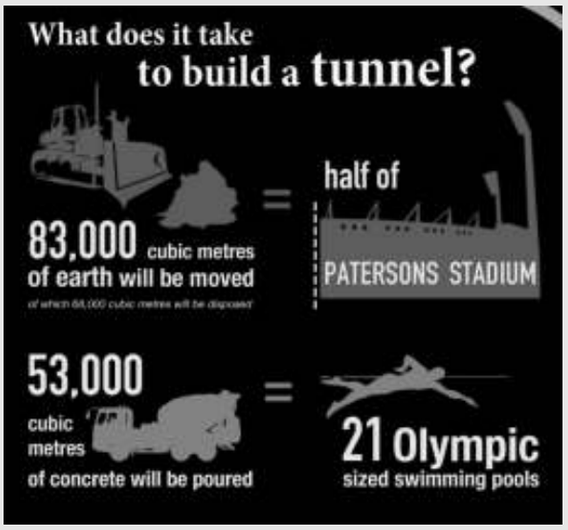
PERTH CITY LINK

Sinking the Freemantle Line from William Street to Lake/King Street is one of the first stages of the Perth City Link. The rail project is supported by all three tiers of government and is scheduled for completion in mid-2014.

The Freemantle line tunnel will cross over the existing Joondalup Line tunnel, leaving just a 1.5 metre gap between the two tunnels. The water logged sand will need dewatering and an estimated 1 gigalitre of water will be pumped out, treated and then pumped back into the ground.

Currently more than 9,300 passengers a day transfer between Perth Station and Perth Underground. To help passengers get from A to B a new 162 metres long 72 metres wide pedestrian underpass will be built to better connect Perth Station platforms to Perth Underground. An estimated 22,600 people per day will use the new underpass by 2031. The number of people using Perth Station is expected to triple by 2031 so a new track will be laid on the Roe Street side of platform 9.





Fremantle Line Tunnel takes shape

Despite the challenges of making sure a very busy central train station continues to operate, the construction is over 45 per cent of the way through and has already achieved some major milestones, such as completing the diaphragm walls for the main tunnel. This puts the project in a good position to finish on time in mid-2014.

The construction is taking place in sandy soil conditions, with a high water table and existing underground structures such as the twin-bored Joondalup Line tunnels. The completed tunnel must also be able to hold the weight of the planned above ground development. This must all be carried out with a rail system operating just metres from construction equipment, in an area surrounded by a number of heritage structures.

The site is located above what was once Lake Kingsford and the water table is less than 1.5 metres below ground level. To remove the water, while ensuring there's no movement in surrounding structures, every drop of water that is pumped out is treated and pumped back into the underground water system. This is done through 323 dewatering wells — 114 wells to pump water out of the ground, 122 to monitor water levels and 77 to put the water back into the ground.

Utility tunnelling project complete in Newcastle

UEA Trenchless has completed a 600 millimetre utility tunnelling project through environmentally sensitive wetlands on the Tomago to Raymond Terrace.

The tunnelling project consisted of three road crossings, including a 110 metre crossing of the Pacific Highway and adjacent wetlands as part of a package of under bores in the Newcastle area. UEA was contracted by Bolte Civil.

The first two drives, both 40 metres in length, were driven across the roads using a guided boring machine laser pilot system, which was followed by a traditional auger borer. This method, which is also known as pilot tube microtunnelling, ensured accuracy of line and level and the auger borer provided a simple and efficient method of inserting the 600 millimetre steel enveloper pipe.

A 450 millimetre PE carrier pipe was then inserted and grouted into position.

The third drive of 110 metres was also completed using the same pilot tube microtunnelling method, ensuring accurate line and level for the enveloper pipe. The 600 millimetre steel enveloper pipe was installed using a combination of auger boring under the Pacific Highway.

This was then switched to a Grundoram hammer to ensure safe passage beneath the environmentally sensitive wetlands and a flowing creek with no surface disturbance.

With less than 600 millimetres of cover, the enveloper was successfully installed and the 450 millimetre PE carrier pipe inserted and grouted into position. UEA said that ground conditions presented hard packed sand through to saturated muds with a high water table.

Tunnels in Perth 'inevitable' to ease congestion

The Transport Minister Troy Buswell says more tunnels through the city are inevitable as Perth's population continues to grow.

The Department of Transport's Deputy Director General has told a parliamentary hearing there is no immediate solution to easing congestion in the CBD.

Mr Buswell says extra tunnels will need to be considered within the next 20 years.

"We're some way from landing on the definition of where those tunnels will go but clearly our road network is becoming full," he said.

"There is a limited capacity to build new roads, and the option that is explored and used right around the world is to tunnel."

Traffic is expected to become more congested as Riverside Drive is affected by the digging for Elizabeth quay on the waterfront.

Mosman tunnel

A tunnel under Mosman taking commuters from Sydney's Northern Beaches to the city would get traffic off through streets, speed up travel times and be a "major win" for residents, Mosman deputy mayor Roy Bendall said. But the plan should not include a bus-rapid transit system operating along the Spit-Military Rd corridor, he added. "I embrace the tunnel option because it would take cars off Mosman's residential streets but we can't lose a lane on Military Rd," Cr Bendall said. "Buses should be accommodated underground."

The tunnel, (which would include bus access), is part of a proposed Northern Beaches Link, connecting the Gore Hill Freeway with the Burnt Bridge Creek Deviation via a new Spit Bridge. It was floated in Infrastructure NSW's 20-year State Infrastructure Strategy, released recently. The plan aims to improve travel times on the Northern Beaches corridor.

There is no existing budget for the project but it could be fast-tracked through private sector investment and a possible toll for Northern Beaches commuters.

MELBOURNE METRO RAIL PROJECT

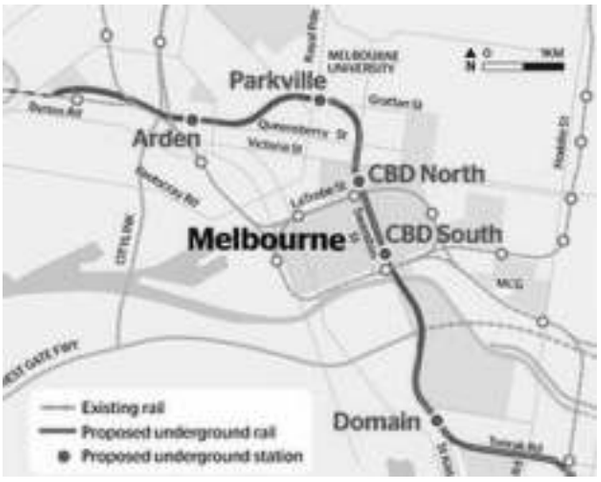
An artist impression of the proposed CBD South Station, which would be built beneath Flinders Street.

Melbourne's trains will become so overcrowded passengers will be increasingly left behind during peak hour, unless work on an underground city rail tunnel begins within two years. State government documents reveal that unless work begins soon on the so-called ''Melbourne Metro'' rail project, several of the city's busiest train lines will come under further strain because the number of passengers will outstrip services.

''In the event of no further infrastructure being provided, all corridors except Sandringham will have significant overcrowding … by 2020. Moreover, it is anticipated that crowding will be so severe on the Werribee, Sunbury and Dandenong lines some passengers will be unable to board the trains in the critical peak hour,'' business case documents reveal.

The long-awaited Melbourne Metro project involves building a 9 kilometre tunnel across the inner city, with five new underground stations between South Kensington and South Yarra: Arden, Parkville, CBD North, CBD South and Domain. The tunnel will in turn link the Sunbury rail line, in Melbourne's north-west, to the Dandenong rail corridor in the outer south-east, allowing an extra 24,000 passengers an hour across the train network.

The Baillieu government regards the project as one of its top infrastructure priorities after the east-west link, an 18 kilometre road connecting the Eastern Freeway and the Western Ring Road. But a business case ''concept of operations'' report, obtained under freedom-of-information laws, has revealed the urgency of the proposal, which requires state and federal funding to get off the ground.



The Department of Transport's June report warns that without the infrastructure the number of ''load breaches'' — where there is an average load of more than 798 passengers in a train — will grow over the next seven years. Projections suggest that by 2020 trains will be overcrowded for at least three hours during the morning peak, and on the Werribee, Sunbury and Dandenong lines, demand will exceed 1200 passengers, meaning many commuters would be left behind.

The Werribee/Williamstown and Frankston lines will start to face ''significant shortfalls'' from around 2015. The Craigeburn, Upfield and Sunbury lines will face significant shortfalls by 2016, and the Sandringham line from 2017. Shortfalls on the Dandenong corridor are ''immediate'' and ''will rise to a severe shortfall by 2020''.

The documents also show:

- The rail project ''will need to be progressively implemented over the next decade, commencing in the next two years''.
- Part of the plan involves upgrading the Dandenong rail line with longer ''nine-car'' trains, timetable changes, signalling upgrades and road-rail separations.
- New branch lines to Rowville and Melbourne Airport (the subject of feasibility studies) are being considered as part of longer term improvements to the network.
- The underground tunnel will not be able to accommodate freight trains, meaning existing freight services that operate during peak time would have to be re-timed.

Transport Minister Terry Mulder described the Melbourne Metro project as a ''city shaping'' plan that will ''fundamentally change the way our transport network operates. More frequent trains, more stations and increased capacity will also deliver significant flow-on benefits to the rest of the transport system, it will take pressure off the major arterial roads including West Gate and Monash Freeways,'' he said.

Infrastructure Australia, which makes recommendations to the federal government about funding of major projects, puts the Melbourne metro rail project at the top of its priority list as one of Australia's most urgently needed projects.

The project has been deemed ''ready to proceed'' and is in the planning approvals stage. Public Transport Victoria says that if planning approval is granted, the start of construction will be contingent on Commonwealth funding, but it is refusing to disclose how much the project is likely to cost.

A similar project for a tunnel from Footscray to Caulfield was proposed by the former Labor government and costed at $4.5 billion for the first stage. Labor's track was about 17 kilometres; the Coalition's tunnel is 9 kilometres. About $90 million in State and Federal funds has been allocated so far.

PTV also admits construction will cause some disruption across the city, but the extent will depend on the precise tunnel route and station design. Community feedback will be sought by the government next year.

THE (POSSIBLE) SOLUTION

A 9 kilometre tunnel under Melbourne to link the Sunbury and Dandenong lines. Five new underground stations:

- Domain (under St Kilda Rd in South Yarra)
- CBD South (below Flinders Street Station)
- CBD North (below Melbourne Central)
- Parkville (under Grattan St and Royal Parade)
- Arden (Queensberry Street)
- Existing northern and Caulfeld rail groups will become four independent corridors, allowing more services on the Craigieburn, Sunbury, Werribee/Williamstown, Upifield, Frankston and Sandringham lines, and longer trains on the Sunbury, Pakenham and Cranbourne lines.
- It would mean an extra 24,000 passengers an hour across the network.

Doncaster Rail link

Yarra Council has completed the first phase study into the Doncaster Rail link. Cr Fristacky said the Victorian State Government's proposed east-west tunnel would cost in excess of $10 billion, effectively depleting the State of essential funds for vital public transport improvements, while exacerbating inner city traffic problems through induced traffic. In comparison, she said the Doncaster rail could be built for around $1 billion.

Melbourne Metro upgrade

Melbourne's underground train network is plagued by safety issues including crumbling emergency tunnels and corroded fire services after years of neglect, Victoria's ombudsman has found.

Acting Ombudsman John Taylor said despite seven engineering reports between 2001 and 2011 highlighting the deterioration of key safety systems in the tunnels, which lie 20 to 40 metres below ground, the Department of Transport had taken "little effective action" to correct them.

Melbourne's busiest stop, the iconic Flinders Street Station, also lacked an effective fire plan, Mr Taylor says in his report, tabled in State parliament. The city loop carries more than 700 train services each weekday and ferries an estimated 130,000 people through its four underground tunnels to Parliament, Melbourne Central and Flagstaff stations.

Mr Taylor criticised senior department officers for showing "little appreciation of the risks" posed by delays to repairing damage to tunnel infrastructure, which was mainly caused by groundwater seepage and resultant corrosion. He also said a 2011 review commissioned by train operator Metro had found drivers lacked safety training on operational risks, emergency management and error prevention.

Mr Taylor said Public Transport Victoria (PTV), which was set up in April 2012, had put in place a comprehensive works plan to remedy the problems since his investigation began. He said Metro had also put in place new management plans for emergency and crisis, and security and terrorism risks, but driver training remained a concern.

Among his 15 recommendations, Mr Taylor urged PTV to ensure Metro upgrades its training for train drivers and station staff to improve their responses in an emergency. He also called on PTV to commission an independent audit of key rail safety infrastructure, with a view to ensuring it makes and keeps safety a top priority.

Government on track to deliver plan for Melbourne's east-west tunnel

Testing from drill sites under Melbourne's inner north had shown that conditions for tunnelling would be suitable.

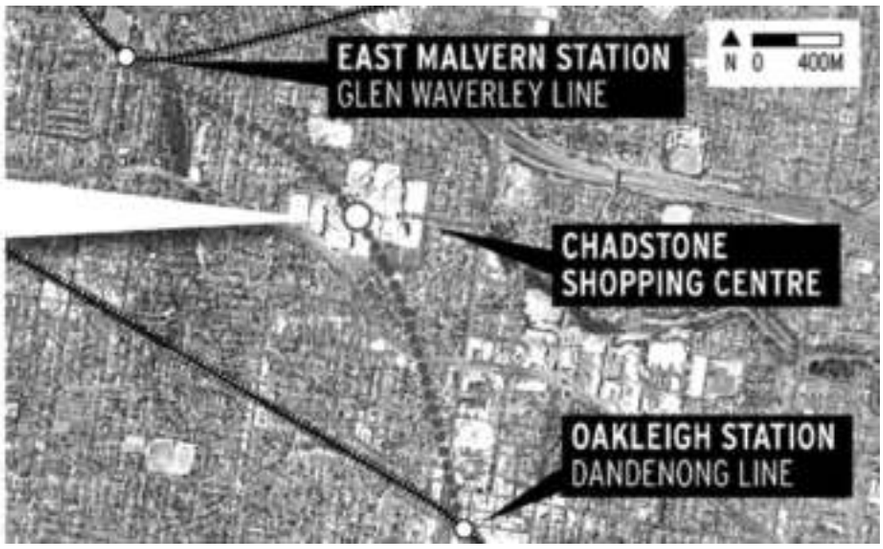
"We've drilled at 43 locations along Alexandra Parade as well as within areas of Carlton, Parkville and Royal Park since May, and it may be that more drilling will be necessary after we receive feedback from the construction industry," State Minister for Roads, Terry Mulder, has announced. "The results so far are favourable. They confirm that an east west link tunnel would most likely be constructed through high strength basalt from the Hoddle St end of the project, before transitioning to Melbourne formation comprising mudstone, sandstone and siltstone around Lygon St."

Mr Mulder said that showcasing the core samples to the construction industry was vital to the future delivery of the project to ensure the private sector had input into the development of what would be Australia's largest road project.

Drillers and protestors at a drill site for the east west tunnel link.

CHADSTONE STATION?

The government is looking at linking the Glen Waverley and Dandenong lines with a subway that stops at Chadstone Shopping Centre.



Burying the Glen Waverley line

A private consortium wants government money to help build the new Chadstone station and subway tunnels, which would remove six of the eastern suburbs' most dangerous level crossings and free up valuable land for development. A new train line connecting the Glen Waverley and Dandenong railway lines would stop at Chadstone Shopping Centre as part of a bold $2 billion plan to bury part of the existing Glen Waverley line.

The heavy-hitting consortium, which includes NAB, Thiess, Hassell, Grimshaw Architects and KPMG among others, has proposed linking Chadstone to the rail network by digging a tunnel between the Glen Waverley and Dandenong lines.

The Victorian government is still considering whether it will include the revised plan, called ''Project Double Fault'', on its already ambitious list of impending railway upgrades. The consortium is seeking a $600 million to $700 million contribution from the government. It says the Chadstone connection would spark a huge increase in rail patronage and help the government recoup its costs.

Chris Eves, a consultant with consortium member Lighthouse Infrastructure, said the project would also fix several rail and road bottlenecks and create capacity to run more trains. It would remove every level crossing on the Glen Waverley line, including two that intersect with tram lines. ''We believe that the Victorian government would achieve major economies of scale if they were to approach the removal of level crossings on a systemic basis,'' Mr Eves said. The deadly smash between a train and a truck at Dandenong proved the government needed to attack the task of removing Melbourne's 170-plus level crossings with greater urgency, Mr Eves said.

The Baillieu government has committed to removing 12 level crossings, but only five of those projects have been funded. ''Our discussions with the [Transport] Department and other agencies indicate that they do not have the financial or human resources to devote to level-crossing removal,'' Mr Eves said. ''This must change. The Victorian government needs to develop a specific authority to devote itself to planning for the removal of level crossings.''

The project requires building five new underground stations at Heyington, Kooyong, Tooronga, Gardiner and Glen Iris. It would create more than 100,000 square metres of valuable new real estate along a corridor up to 50 metres wide and more than 4 kilometres long. The consortium would not own this land and would still have to tender for the right to develop.

Kelly O'Dwyer, the federal Liberal member for Higgins, which takes in the affected land, said it was an innovative proposal that ''deserves very serious consideration''.

A spokesman for Public Transport Victoria confirmed the authority had met consortium representatives, and said the proposal was being assessed against several other transport development plans, including the proposed Melbourne Metro rail tunnel from South Kensington to South Yarra. A spokeswoman for Public Transport Minister Terry Mulder would not say whether the proposal was being considered but said the State needed private investment in transport.

Tony Morton, president of the Public Transport Users Association, warned that the Chadstone connection could further tangle the network, which needed to be more streamlined to operate efficiently, and could potentially confuse passengers on the Glen Waverley and Dandenong lines.

It would create more than 100,000 square metres of valuable new real estate along a corridor up to 50 metres wide and more than 4 kilometres long.

Esperance Port Access Corridor

One of the key components of the Esperance Port Access Corridor Project in WA is the constructionof a railway tunnel located along the current railway track under the realigned Harbour Road between Cook Street and Scott Street. Main Roads Western Australia awarded a Design and Construct contract to John Holland in March 2012 to undertake the works. The railway tunnel is the major milestone and commenced in November and construction on the realignment of 1.8 kilometres of Harbour Road and 1.3 kilometres of the existing railway between Mungan Street and the Esperance is now well underway.

John Holland is working with a range of stakeholders from Main Roads, the Port, local residents, local Government and service authorities to minimise disturbances. Current rail and road operations must be maintained which means that there is a 12 hour window once a month to work on the rail line.

An artist's impression of the Port Access Corridor project was created so that locals can see for themselves what the project looks like with all the components, such as the tunnel, the bridge and the new placements of the railway and road and has been generally well received by the public.

Redbank tunnel will soon be history

The Redbank Tunnel will be filled with rock, sealed and revegetated in the coming months as Xstrata Coal completes its multimillion dollar project to divert the railway line in north Tahmoor in NSW. Xstrata began diverting the main southern line around Redbank Hill in June last year in the "interests of safety". Tahmoor Colliery expects to start mining under the tunnel later in 2013.

An Xstrata Coal spokesman said there was a chance the tunnel could have subsided when longwall mining had reached the area. "Subsidence was predicted to be more substantial while mining took place directly underneath it [Redbank Tunnel]," he said.

The first train travelled across the new track in December 2012 after more than 1.5 kilometres of track was moved around Redbank Hill. Xstrata expects to finish the project in June 2103, which includes re-vegetating the area.

Noise levels will be measured in the coming months to ensure the projections made before the line was moved are accurate.

Xstrata offered short-term relocation to people living close to the construction in December when the tracks were commissioned and the work was around the clock.

Railway historian James Whitfield of Tahmoor said that the safety of passengers and railway crews was paramount. "The Redbank Tunnel at Tahmoor really has little historic significance unlike the original single line tunnel at Picton," he said.

Thiess awarded Narrows contract

Thiess Tunnelling has been awarded a $134 million contract by Saipem Australia, the national arm of worldwide pipeline specialist Saipem, to construct a tunnel for the Santos GLNG project in Gladstone.

Thiess will construct a 4.3 kilometre tunnel under a body of water known as "The Narrows" to connect the mainland near Gladstone to Curtis Island where Santos' Gladstone liquid natural gas plant is located. The tunnel, to be 3.4 metres in diameter, will serve as the conduit of the Santos GLNG gas transmission line.

Thiess managing director Bruce Munro said the contract with Saipem was a strong endorsement of the company's tunnelling expertise.

Meanwhile a central Queensland environmental group says piping gas to Curtis Island via undersea tunnels will have minimal impact on water quality in the Gladstone Harbour.

Santos GLNG says for environmental reasons it will dig a tunnel for the pipeline to its $16 billion gas liquefaction plant off the mainland. The company says its original plan was to lay the gas pipeline on the seabed.

Capricorn Conservation Council spokesman Michael McCabe says it is the preferable method but he has some reservations about digging through a fault line. "We understand it's a very stable geological fault," he said. "We'd like to see some technical information to make sure there are no major concerns when they move from one type of rock or sediment surface to another through that fault line and to make sure all things are stable and disposal of drill material is managed properly."

He says it is a better way to get the gas off the mainland. "Our understanding from the original input to the EIS [environmental impact statement] was that any method that had less disturbance to the harbour, the water quality, would be preferable," he said."The original debate was whether all the companies would bundle their pipelines. "We'd like to see more technical details but if it's not going to add to any disturbance from dredging it seems like a better option."

Tunnel plan approved for Parramatta's Lennox Bridge

The current regime at Parramatta Council is determined to debase the city's colonial heritage, a leading advocate has said.

The council voted recently to tunnel through either side of the historic Lennox Bridge to allow pedestrians and cyclists easier access from one side to the other.

Parramatta and District Historical Society president Trevor Patrick called the decision "an absolute tragedy" but said it was just one of several council ideas that downgraded the city's heritage. Mr Patrick said the bridge, designed by David Lennox, was one of the oldest in Australia and there were only three like it.

But not everyone is unhappy about the Lennox Bridge plan. Councillor and former lord mayor Lorraine Wearne said the portals would allow public access from the CBD along the foreshore to Parramatta Park. She said the bridge had already been modified so that it would not be damaged by floods and further changes would not diminish its heritage value.

The NSW Heritage Council supported the $3.6 million plan despite previously writing a submission that said it would "seriously and irrevocably compromise" the structure. The portals will be paid for mostly by a federal government grant and must be completed by June 2013.

SYDNEY OPERA HOUSE VAPS PROJECT

The Vehicle Access & Pedestrian Safety Project (VAPS) is an important milestone in Sydney Opera House's history. Funded by the NSW Government, the project will enhance tourist and visitor safety by removing heavy vehicle movements from the forecourt to a purpose built underground roadway and loading dock accessed from the southern end of the site, near Macquarie Street. This will allow pedestrians to have safe and exclusive access to all the Sydney Opera House facilities at forecourt level.

John Holland is the contractor responsible for the excavation and construction of the new underground loading dock and upgrade of the forecourt roadway. Work commenced in January 2012.

The contract, with an approximate value of just over $100 million, is part of the $152 million upgrade of Sydney Opera House and is the biggest building works on the site since its opening in October 1973.

Costs strangle Hobart tunnel vision

Hobart Lord Mayor Damon Thomas admits his vision for a tunnel under Macquarie St is dead "at this time" but the concept remains alive in his longer term dreams for the city. Alderman Thomas also would like to investigate a ban on traffic along part of Campbell St to create a "walking precinct" around the Menzies Centre and Royal Hobart Hospital.

A council report, based on modelling by consultant GHD, has costed a tunnel linking the Southern Outlet to the Tasman and Brooker highways at $1.5 billion to $3.7 billion.

Ald Thomas, who championed the idea, admitted that the plan was "obviously way too expensive". But he will not let the idea die. He was buoyed by the finding that the tunnel could shave up to six minutes off a journey through the CBD in peak-hour traffic and believes a "cut-and-cover" tunnel could be more feasible.

Adelaide Glass tunnel proposed

A proposal to build a glass tunnel along the bed of the Port River will be considered by the local council. The tunnel would run directly beneath the Birkenhead Bridge and allow tourists a closer look at the Port River dolphins. Port Adelaide mayor Gary Johanson says it would also allow pedestrians to avoid crossing a very dangerous part of road. "A lot of people are now playing Russian roulette walking across the road at the foot of the Birkenhead Bridge and it's impractical to put a pedestrian crossing there," he said. "What I'm looking at is a viewing tunnel. "By going under the water there it's protected, no boat is likely to moor over it and drop and anchor through it or anything like that."

He says the river has been cleaned up since sewerage stopped being pumped into it a number of years ago. "That's why you see dolphins there now," he said. "It may not be as dear as you think because we're only talking the width of the Birkenhead Bridge so what it does is it forms a safe passage from one side of the bridge to the other for the tourists. "Admittedly the river can be dirty on quite a few days of the year but on the days where it's clear, it wouldn't be long before the dolphins realised they could get closer to people without people touching them."

Port Adelaide mayor Gary Johanson says it would also allow pedestrians to avoid crossing a very dangerous part of road.

Victoria Park Tunnel wins international award for construction methodology

The Victoria Park Alliance was presented with the 2012 International Road Federation (IRF) Global Road Achievement Award for 'Construction Methodology' for the Victoria Park Tunnel project in Auckland, NZ. The award was presented in Washington, DC.

The Alliance comprises the New Zealand Transport Agency, Fletcher Construction, Beca, Higgins Contractors and Parsons Brinckerhoff.

Victoria Park Alliance Manager, Andrew Rose, said this global award recognises the exceptional effort of a high performing, integrated team. "The Alliance team tackled complex consenting, design, construction, environmental, and lifecycle issues on the project. The success of the project relied on rigorous planning and the coordination of staged construction of the tunnel. We were working within a tightly constrained, high-profile corridor and community support was critical to delivery. The team won stakeholders' trust by maintaining crucial services and traffic flows across the tunnel alignment; rehabilitating three historic landmarks; developing award-winning safety practices; and enhancing the local supply chain," said Mr Rose.

Parsons Brinckerhoff was involved in concept design for the tunnel systems, inputs to the target outturn cost (TOC) and planning the procurement of the tunnel systems fit-out. The team also created a three-dimensional model, allowing stakeholders to 'fly through' and explore the project before construction began.

Parsons Brinckerhoff Design Manager of Tunnel Systems in Australia/New Zealand, Mike Reed, said the project set a new benchmark for construction project delivery in New Zealand. "This award indicates we have also set a new world benchmark," said Mr Reed.

The IRF Global Road Achievement Award winners are selected by an independent, international panel of judges with expertise in the roadway development industry. The Alliance joins an elite group globally recognised for their innovation in road projects. The awards ceremony took place at the annual IRF awards luncheon on 15 January 2013 in Washington DC.

Lyttelton Tunnel

Traffic drops since quake

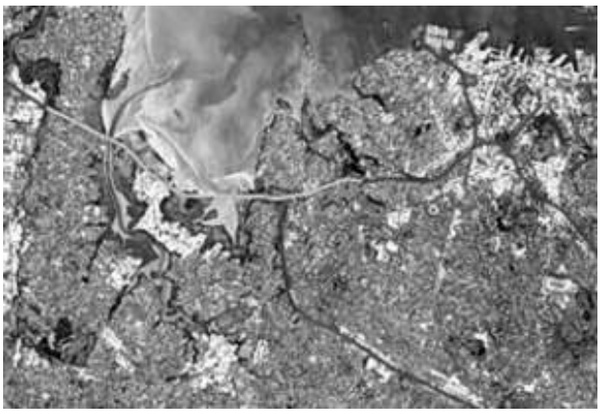
Motorists seem to be too scared to drive through the Lyttelton Tunnel for fear of a major aftershock. There is certainly a big drop in traffic using it with NZ Transport Agency (NZTA) figures showing about 2000 fewer cars travel through the tunnel each day now than before the February 2011 earthquake.

This excludes heavy traffic, which has increased by 5 per cent because of the closure of the Evans Pass-Sumner road and demolition material being taken to the port.

Tunnel building to be demolished

The Lyttelton Tunnel control building, designed by the late Peter Beaven, will be demolished because of earthquake damage. The NZ Transport Agency (NZTA) said the building was considered dangerous and it had asked the Canterbury Earthquake Recovery Authority to demolish it. The category 1 heritage-listed building was red-stickered after the quakes because of rockfall risk.

NZTA highways operations manager Pete Connors acknowledged the news would disappoint some, but the agency had looked exhaustively at repair options and worked with the Historic Places Trust to try to save it. A 2011 report put the repair cost at more than $3.5 million over the cost of a new building. A replacement building would reflect Beaven's design and be built away from the rockfall path, he said.



Waterview Connection on track

The NZ Transport Agency says excavation work for the first of the Waterview Connection's two 2.4 kilometre long motorway tunnels beneath suburban Auckland is on-track to begin in 2013, with a ceremonial ground-breaking for a 30 metre deep trench needed for the construction of the project's twin tunnels carried out in August 2012.

The Prime Minister, John Key, officially turned the first soil for the excavation of the tunnels' southern approach trench in the west Auckland suburb of Owairaka.

The trench, which will be excavated to a depth of 30 metres, will be where the 85 metre long tunnel boring machine will be assembled before beginning work excavation of the tunnels next year.

NZTA State Highways Manager for Auckland and Northland, Tommy Parker said a range of preparatory works and environmental controls have already been put in place to facilitate the start of construction. These include the provision of alternative open space, realignment and rehabilitation of parts of Oakley Creek and the relocation of local wildlife and plant life to new habitats.

The five kilometre Waterview Connection, including two 2.4 kilometre tunnels between Owairaka and Waterview, will provide a new six-lane motorway link between SH16 (the Southwestern Motorway) and SH20 (the Northwestern Motorway) to complete Auckland's Western Ring Route. It is New Zealand's largest and most complex roading project to date, and one of the seven Roads of National Significance identified as key to enabling economic growth for New Zealand.

Mr Parker said when the southern approach trench was complete, the tunnel boring machine would descend to 45 metres beneath the surface, passing below hard volcanic rock and leaving intact the open space, communities and commercial precincts above.

"To create the launch pad for the machine, we first have to excavate through a significant chunk of this basalt to reach the softer soil conditions below, and that is the process we have officially begun today," Mr Parker said.

Excavation of the trench will involve a series of controlled explosions to fragment hard rock.

"This not only allows the excavation to be carried out faster, it also significantly decreases the impact felt by local residents as it reduces the amount of traditional rock-breaking activity required. Basalt retrieved through this process will be used throughout the project, and for landscaping."

Mr Parker said the project strikes a balance between contributing to the economic development of Auckland and New Zealand, and meeting the needs of the project's surrounding communities.

"In addition to local landscaping initiatives around Owairaka and Waterview, the project will, in partnership with Auckland Council, also provide enhanced walking and cycle ways between the two communities. These elements are vital components of the overall project scope, as we work to deliver this key transport link for Auckland."

Watch a 3D animation of how the Waterview Connection project will be built online at www.nzta.govt.nz/waterviewconnection/ or www.youtube.com/wcnow/

Christchurch company honoured with safety award

Drain Surgeons is the latest company to win the Stronger Christchurch Infrastructure Rebuild Team's (SCIRT) Bill Perry Safety Award. Drain Surgeons has been working for delivery team City Care, assessing the state of the city's earthquake-damaged pipes at all hours of the day and night.

The award recognises Drain Surgeons' focus on SCIRT safety targets and building a positive safety culture. Additionally, Drain Surgeons has introduced a number of safety innovations to eliminate or isolate workers from hazards. Drain Surgeons has been undertaking CCTV operations as one of City Care's main contractors — investigative work, videoing the wastewater and stormwater systems, and identifying issues caused by the earthquakes in preparation for repairs.

This work is often carried out through 24-hour operations on multiple sites and manholes, often in the middle of the road, needing traffic management. SCIRT General Manager Duncan Gibb said "The company has an outstanding safety record backed up with site audits and they happily share their innovations with other companies in the pipe investigation and assessment industry."

Thermal cameras for Homer Tunnel

Thermal cameras and 24-hour monitoring will be part of a multimillion-dollar safety upgrade to the Homer Tunnel.

The New Zealand Transport Agency's Southland highway manager, Peter Robinson, described the planned safety improvements to the regional transport committee at Environment Southland yesterday. The committee is made up of representatives from the regional council, Invercargill City, Southland District and Gore District Councils, the NZ Transport Agency, and other experts.

The extra safety improvements include an extra satellite phone, thermal and infrared cameras, and live monitored video streaming.

Mr Robinson said the Homer Tunnel had one of the highest risk profiles in New Zealand. "The safety implementations we are working on will halve that risk profile." Mr Robinson said the project would cost between $120 million and $150 million.

The NZ Transport Agency state highway network operations group has been looking at ways to improve safety on the Milford Rd, particularly in the area around the tunnel. That part of the country did not experience the "typical three-month winter", Mr Robinson said, and could experience snow and winter conditions between May and December each year. About 3 kilometres of the road was at a 10 per cent gradient and while a "good" bus could handle this, some were at risk of catching fire, he said. There have been five bus fires in the area since 2002, one inside the Homer Tunnel.

With no power and water supply in the area, no cellphone or general radio reception, high rainfall and an emergency response 40 minutes away, the area presented numerous challenges, he said. The extra satellite phone meant three would be available at the ends of the tunnel, and the new phones would mean all could be used at the same time if needed. Currently only one can be used at a time.

External cameras, which took a still photo every two minutes, would have a live video feed which would be continually monitored. High bandwidth radio links and a microwave system would need to be installed, and the transport agency was applying for the consents, Mr Robinson said. The cameras would monitor the road, the sky and the mountains, and could be remotely operated.

Electronic screens had been installed at the entrances to the tunnel and alerted drivers to expected wait times for entering the tunnel. The message could be changed if there was an emergency and they could not enter. Cameras inside the tunnel would monitor the number plates of vehicles entering and leaving the tunnel, sounding an alarm if they did not match up.

Infrared and thermal cameras would detect if a vehicle had stopped in the tunnel, if a person was on the road, and if vehicles were speeding up or slowing down. In the event of a fire in the tunnel, the thermal camera could detect where people were if they were not visible in the smoke.

Central Interceptor Tunnel

The council-controlled organisation Watercare plans to build an underground tunnel to carry sewage and stormwater from central Auckland to the Mangere water treatment station. It would then be treated and released into the Manukau Harbour.

Watercare spokesman Daniel Wrigley says the tunnel will ensure Auckland's wastewater system copes as the city grows. There are around 100 locations in central Auckland where wastewater overflows from the current pipe after bad weather and the new system should reduce that by at least 80 per cent, he says. But many Mangere Bridge residents are concerned about the impact the tunnel would have on their community.

Residents' concerns originally centred around the three-metre tall air vent that was proposed for the Ambury Park end of Kiwi Esplanade. But now they have worries about the wider project.

Mangere Bridge resident Ken Duff says the amount of water that would be deposited into the Manukau Harbour if the project went ahead is also alarming. "What you're doing is shipping a lot of stormwater from its natural catchment into Mangere which then puts it into a shallow harbour with a finite ability to handle it," he says. "So there are big ecological risks in that."

Second Mount Victoria tunnel

Although construction of a duplicate Mount Victoria tunnel has yet to be formally confirmed, the NZ Transport Agency has set a start date. Wellington highways manager Rod James said "It's in our program for a 2018 construction start." The flyover interchange will deal with congestion problems at the Basin Reserve but "the tunnel will become effectively the choke point at certain times", he said.

The project will also include widening three Hataitai roads — Taurima St, Ruahine St and Wellington Rd — to create a four-lane road from Wellington urban motorway to the airport, Mr James said.

Whether the new tunnel would be south or north of the existing one has not been decided, but the agency already owned all the land it needed for the project. The new tunnel and widened roads are part of the Government's Roads of National Significance program.

There will be concerns in the Mount Victoria community about its impact, and Hataitai Kindergarten's building would need to be demolished or moved.

WELLINGTON TUNNEL UPGRADES

This project brings two key tunnels in Wellington's road transport network into line with modern, international standards.

The Wellington Tunnel Alliance (WTA), comprising the New Zealand Transport Agency, Leighton Contractors, SKM and AECOM, have successfully refurbished the Mount Victoria and Terrace tunnels in New Zealand's capital.

Both tunnels are on State Highway 1 and are vital links in the national road transport network. Traffic in the existing tunnels is bidirectional, with over 40,000 vehicles per day using the Terrace Tunnel. In addition, thousands of pedestrians and cyclists use the Mount Victoria Tunnel daily to travel between the city and the eastern suburbs.

The tunnel systems were near the end of their design life, and the existing infrastructure falls short of the standards expected of modern urban road tunnels. Upgrading them involves construction of new tunnel infrastructure including fire control systems, ventilation systems, lighting, drainage and seismic upgrades.

The physical works were carried out with minimal disruption to road users. An innovation on the Terrace project was the creation of a 100 square metre working deck which can be raised and lowered. It provided a very safe work platform compared with alternatives such as scissor lifts. It also provided safety during the day when the tunnel was open to traffic, by isolating demolition debris and removing potential driver distraction.

In an international first, the Alliance applied the Tunnel Refurbishment and Enhancement Process (TREP) developed jointly by Leighton Contractors, SKM and Aecom. This is a holistic refurbishment program which addressed the challenges of upgrading infrastructure that, in the case of the Mount Victoria Tunnel, is up to 80 years old. The process combined a risk-based analysis of the fire and life safety situation in the tunnel with the 'safety file' approach adopted in Europe and a scientific decision making process to rank and select alternatives.

The outcome of the Terrace Tunnel refurbishment is a 'smart tunnel' that can be operated and maintained efficiently, with inbuilt emergency systems that can detect and minimise loss in the event of an incident in the tunnel.

Basin Reserve Tunnel

The NZ Transport Agency investigated constructing a tunnel under the Basin Reserve, but it proved impracticable, Wellington highways manager Rod James said. The former swampland was too wet and potentially liquefaction-prone in a major earthquake, he said. It would also have resulted in a steep grade from Mount Victoria tunnel down to a Basin Reserve tunnel.

Bridge-building in that environment was far easier and cheaper than tunnel-building, he said. "Our estimate for building a tunnel is $260 million and this [the flyover] is $90 million. To be honest, building a $260 million tunnel is not affordable so, in reality, it is a do-nothing option." About 36,000 vehicles travel around the Basin Reserve each day.

The flyover is expected to remove 18,000 west-bound vehicles. It effectively removes all traffic that conflicts with north-south traffic at the Basin Reserve.

Vector tunnel drama

Transpower will review its processes after five men believed to be missing in an Auckland tunnel sparked a full-scale emergency callout in December.

The Transpower maintenance staff were working in a Vector cable tunnel below Nuffield St, Newmarket for most of the day, but failed to make contact with their supervisor above ground at 7.30pm. There was no word from the men for three hours before they were found safe and well by the Fire Service about 11pm.

"There was no incident at all underground or in the tunnel, it was purely a communication breakdown," Transpower spokeswoman Rebecca Wilson said. "We have a protocol in place that we check in with those people in that tunnel because it's underground or in a confined space. We check in with them every 30 minutes. "Obviously we contacted emergency services when we hadn't heard from them," she said.

Wilson said the company would review its processes. "This is not something that happens frequently. The process is in place essentially because the tunnel is a confined area, but we are reviewing the reason for that loss of communication and we will investigate and obviously rectify what it was."

Auckland rail tunnel investment opportunity

The Employers & Manufacturers Association says the Government needs to look at a railway tunnel in central Auckland as an investment, rather than a burden.

A government report suggested that a rail tunnel through the central city is the only viable long term option for Auckland's transport demands. Transport Minister Gerry Brownlee has said the report is just a valiant attempt to make the project stack-up.

But EMA chief executive Kim Campbell said that attitude is not going to help solve the problem and the Government needs to look at the tunnel as an investment. He said the roll-on effects, including jobs, investment and a more efficient city, can only be good for the economy and the Government.

Hunua 4 Watermain Project

The Hunua project is the biggest water pipeline project undertaken in New Zealand for many years and involves 30 kilometres of 1.3 to 1.9 metre diameter steel pipeline traversing Manukau and Auckland cities. It involves the crossing of Manukau Harbour, three motorways, three railway lines, a creek and eight streams.

To date 324 m of pipe work has been completed. The main construction started in early 2012 and final commissioning is expected in 2016. In sensitive areas — such as busy intersections — specialised construction methods will be used such as tunnelling or pipe bridges.

When completed, this project will substantially improve security of water supply to the city's 1.3 million people. The lifetime of the Hunua 4 watermain is estimated to exceed 100 years, and its functionality, design and structural integrity is of significant importance to Auckland and New Zealand.

Opportunities in tunnel design and construction in Asia

Three tunnelling authorities share their views on the current untapped opportunities in the Asian tunnel design and construction landscape and explain why the vast potential in tunnel design is still not tapped.

R.K Dayal, Additional General Manager, RITES:

There is vast potential which is still not tapped and opportunities existing in tunnelling design and construction in India in the field of "Submerged/ Underwater bored Tunnels".

There are almost no parties in India to deal with these potential fields though a large market exists for tapping. Also, in the Himalayan region more and more projects are being designed for construction with the NATM approach and the Contractors are gearing up to update themselves with suitable men and machinery.

Dr. Lim Seok San, Geotechnical Manager, Samsung:

In the Asian region, tunnel design and construction has focussed on developing civil infrastructure of the type already mentioned. Untapped opportunities for the future could be deep tunnelling and utilisation of space created below ground. Construction of underground facilities such as stadia, theme parks, museums, and hotels could be considered to replace old facilities in city centres, providing easy access. Use of this kind of underground space has advantages by way of energy saving, land use and earthquake resistance. Of course, implementing plans for such use of below ground space would need wide social agreement.

Another interesting topic is the study of tunnel design and construction based on different gravity conditions. This will provide the technique and ideas for the possible future construction of tunnels in, say, the Moon or Mars so as to develop space camps.

Heinz Ehrbar, Chief Construction Officer, ALPTRANSIT GOTTHARD AG:

The tunnelling industry has reached a high standard especially in the field of the tunnel boring machines but also with new techniques for conventional tunnelling. Nevertheless there are still big fields where better techniques can be developed, especially for tunnelling in bad ground conditions as e.g. in squeezing rock. Even with the actually high standard safety of work can and should always be increased.

Heinz Ehrbar, Dr. Lim Seok San and R.K. Dayal will be speaking at Tunnel Design & Construction Asia.

For more information about the event log on to www.tunneldesignconstruction.com

DELHI METRO

Terratec delivers first TBM

Terratec recently delivered the first of six machines to Delhi Metro's Phase III program. Representatives of the client — a joint venture between Metrostroy of Russia and ERA Infra of India — attended the official ceremony.

Designed specifically for the project, the 6.61 metre diameter EPB shield incorporates features such as a VFD electric-driven cutter head, versatile cutting tools that are interchangeable with 17 inch (432 millimetre) roller disc cutters, active-type articulation for the shield, and the tail's built-in two-liquid back-filling system.

The JV intends to use a total of two TBMs for excavating the tunnels between Kashmere Gate and Jama Masjid stations — all part of Delhi Metro Contract CC-07. Each TBM will bore a total combined distance of around 2 kilometre. The lining will comprise 1,400 millimetre wide universal reinforced concrete segments with outer and inner diameters of 6,350 millimetres and 5,800 millimetres respectively.

Delhi Metro's Phase III focuses on more of the outlying areas and, when complete, the network will cover around 70 per cent of the city.

Mandi House tunnel to add to Metro glitter

Despite a distance of only 700 metre, the tunnel coming from Mandi House to ITO on the heritage line will be an engineering feat for Delhi Metro.

Located 16 metres below ground, the tunnel will cross not only the existing underground Metro track but also the railway track at Tilak bridge. What makes the construction of the tunnel a challenge is the zero-settlement goal by Delhi Metro. Settlement is the soil loss experienced during tunneling.

"Though settlement up to 10mm is allowed in such constructions, we are aiming for zero settlement along the existing metro and Railway tracks," said the Delhi Metro Rail Corporation (DMRC) spokesperson. The tunnel alignment is what has prompted Delhi Metro to opt for zero settlement. "We want all cavities to be filled at these two points as they are sensitive since they come under existing tracks. In fact, monitoring will be carried out 24/7 during the tunneling period," added the official.

The alignment will also go under Lady Irwin College and then the neighbouring railway colony before it comes out behind the existing barricades set up by Delhi Metro at the ITO intersection. "The cavities created during settlement will be filled with grouting immediately along the erection of the segments of the tunnel," said the official. Delhi Metro will monitor 30 metres around the tunneling area, also called the influence zone, during this period.

Delhi Metro's Phase III focuses on more of the outlying areas and, when complete, the network will cover around 70 per cent of the city.

The TBM for the heritage corridor was lowered at Mandi House two months ahead of schedule. This came out in front of the ITO station in February. Two tunnel boring machines (TBM) will be used for the tunneling — one for the up line and the other for the down line. The new tunnel incidentally will be going 7 metres below the existing Blue line (Dwarka-Noida/Vaishali) of the Delhi Metro network. It will go under the ramp, before the existing metro track comes out from under the ground after Mandi House. The tunnel for the heritage line will then go around 15 metres below the railway track at Tilak bridge.

Work on the rest of the corridor — all the way to Kashmere Gate via Delhi Gate, Jama Masjid and Red Fort — is expected to take off soon as well, says Delhi Metro. "Preliminary work has already been done at Delhi Gate and Jama Masjid. The moment we get approval from National Monuments Authority (NMA), construction will start," said an official.

The heritage line starts from Central Secretariat. Sources said that if work continues at the present rate, the work may be over before the deadline set for late 2015.

National TBM record in Himalaya

SELI SpA Double Shield TBM "SHILA" has achieved the highest record of 816 metres ever in India during the month of November 2012 at Kishanganga HE Project, during the excavation of the 6to10 metre diameter 14,630 metre headrace tunnel.

The Kishanganga Hydroelectric Plant is part of a run-of-the-river hydroelectric scheme that is designed to divert water from the Kishanganga River to a power plant in the Jhelum River basin. It is located 5 kilometres (3 miles) north of Bandipore in Jammu and Kashmir, India and will have an installed capacity of 330 Megawatts. Construction on the project began in 2007 and is expected to be complete in 2016. Construction on the dam was halted though by the Hague's Permanent Court of Arbitration in October 2011 due to Pakistan's protest of its effect on the flow of the Kishanganga River (called the Neelum River in Pakistan).

New drainage tunnel in Hong Kong

Hong Kong's northwest Kowloon area has been brought a step closer to a safer and drier environment following the commissioning of the long-awaited Lai Chi Kok drainage tunnel.

Designed to cope with periods of intense heavy rainfall, the US$220 million tunnel has taken four years to construct and will also provide flood protection to other areas, including Lai Chi Kok, Cheung Sha Wan and Sham Shui Po.

The 3.7 kilometres of tunnelling comprises six intakes that will convey stormwater through a branch tunnel into the main tunnel, discharging subsequently into the harbour. This will reduce the volumes of stormwater entering the urban drainage system, thereby increasing overall flood protection.

The TBM-bored tunnel was driven around the urban periphery, thereby minimising downtown disruption, and also bored under four operating railway lines and past numerous infrastructural foundations in the busy district of Lai Chi Kok. To avoid any impact on these facilities, the tunnel was driven under a hyperbaric pressure of 4.2bar, thought to be a record for Hong Kong.

The tunnel is one of a series designed to provide flood protection to Hong Kong. Last August saw the commissioning of the Hong Kong West drainage tunnel, while the Tsuen Wan drainage tunnel is scheduled for completion next summer. Also underway is the Happy Valley underground storm water storage scheme.

Anhui's longest highway tunnel begins construction

In China, the 7,530 metre long Mingtangshan Tunnel- part of the highway connecting Yuexi county, Anhui province, to Wuhan, the capital of Hubei province — has begun construction. It is currently the longest tunnel among all of Anhui's tunnels, existing and under-construction.

Yuewu Highway is about 180 kilometres long, with the Anhui section stretching 46.24 kilometres. The project begins at Lianyun village, Yuexi county, and ends at Dafengshu Mountain, the provincial boundary of Anhui and Hubei.

Since the Yuewu Highway crosses many mountainous areas, it consists of many tunnels and bridges. The whole highway has 21 large bridges and 10 tunnels, including Mingtangshan Tunnel. The total length of bridges and tunnels is 26.53 kilometres, accounting for nearly 60 per cent of the total length of the highway.

India's longest rail tunnel opens

A ging Mahtab Jan (75) has never seen train except on television. Jan along with other hundreds of villagers of Hiller Shahabad village in south Kashmir's Qazigund area squatted on the railway tracks, though to stop the first trial run to the country's longest dream tunnel project, which connects the Kashmir valley with the rest of the country.

The 11 kilomentre railway track, which cuts through the foothills of the Pir Panchal mountain, has not only bridged the two passes of the mountain but infused a sense of hope of prosperity and development among the villagers along the tracks, who are for the first time witnessing a running train.

"We will not allow trial run to happen till we will get a station for local villages of Hiller Shahabad," said Jan, who joined the chorus of slogans "Narai takhbeer, Allah Akbar, train ko wapas karoo (God is great, return the train).

The excited and impatient villagers stopped the first trial run for hours together, demanding a halting point for a local village. Indian Railways senior official AP Mishra failed to convince the protesting people and decided to call off the run. "We have to see the feasibility first," said Mishra.

The tunnel accomplishes a dream project of former prime minister IK Gujral, who laid the foundation stone in 1990s, and of former prime minister Atal Bihar Vajpayee, who declared it a national project, the tunnel is an engineering marvel. "This outstanding tunnel is 100 per cent waterproof and equipped with fire fighting system throughout the entire length of tunnel.

"The methodology adopted for construction of this tunnel is by New Austrian Tunneling Method (NATM) where the geological stress from the surrounding rock is used to stabilise the tunnel hole. It is one of the challenging and marvelous projects in Indian civil engineering history," said Indian Railways officials in Srinagar.

The Rs. 1300-crore tunnel is bound to be a major tourist attraction after the 2.75 kilometre Jawahar tunnel on Srinagar-Jammu highway. The new tunnel is second longest in Asia after Chinese one. The tunnel passes 440 metres below the existing Jawahar Tunnel. With the speed of 100 kilometres per hour, it will take around seven minutes to cross the tunnel. The entire project between Dharam, across the Jawahar tunnel, and Qazigund in the valley is 56.54 kilometres, which comprises of 14 tunnels of total length of 44.50 kilometres and 48 numbers of major and minor bridges.

The highlight of the section, which will enable commuters to travel right up to Baramulla through Srinagar from Banihal, is the 11.2 kilometre long tunnel under the Pir Panjal mountain range, billed as an engineering marvel.

The tunnel, which also has a service road running parallel to the track is the second longest in Asia, is constructed at a cost of Rs 1300 crore.

It took almost 7 years to complete the tunnel. About 7,500 tonnes of steel, 3,28,000 cubic metres of concrete has been used and 10,00,000 cubic metres of underground excavation has been done to complete the tunnel.

About 1300 workers and 150 engineers worked round the clock to accomplish this challenging task, Northern Railways said. The section comprises 39 bridges which include 2 major ones, 30 minor bridges and 7 road over bridge and road under bridges. The tunnel has been constructed by New Austrian Tunnelling Method (NATM) which was used for the first time on such large scale in India. The tunnel has been made water proof by providing continuous PVC membrane between primary and secondary lining and is equipped with the state-of-the-art air quality monitoring system, ventilation system, communication system etc.

Two tunnels and a flyover to ease traffic in Mumbai

The growth of Bandra-Kurla Complex (BKC) as a business hub has led the Mumbai Metropolitan Region Development Authority (MMRDA) to chalk out a plan to ease the flow of traffic at the Bandra end of the complex.

The MMRDA will build two underground tunnels and a flyover to tackle traffic from BKC to the Western Express Highway, and towards the Bandra-Worli sea link. The three constructions are expected to be ready by 2014-end. One 1.5 kilometre long underground tunnel will stretch from BKC's E block till beyond Kherwadi junction. This will take traffic from BKC to the Western Express Highway.

Another 400 metre underground tunnel, also starting from E block, will stretch till the approach to the Bandra-Worli sea link. The authority also plans a flyover connecting the sea link to BKC.

"We will be inviting tenders for the project by December. The whole project is likely to cost us Rs400 crore," metropolitan commissioner Rahul Asthana said.

At present, nearly 29,861 vehicles enter the Bandra-Kurla Complex through the Kalanagar junction. Of this, 36 per cent comes from the sea link, 32 per cent from the Western Express Highway and 32 per cent from Dharavi. All these vehicles end up getting stuck in the traffic at Kalanagar.

The stretch from Kalanagar junction till Kherwadi is one of the most congested and gridlocked prone roads in Mumbai as traffic from four major roads converge on this stretch. The road attracts traffic from the BKC, the Bandra-Worli sea link, Mahim causeway and Dr Ambedkar Road, headed for western suburbs. Also, traffic entering the BKC is expected to increase greatly once the diamond bourse there gets fully operational.

MMRDA has said that with the number of vehicles in BKC increasing, it has to improve BKCs infrastructure to maintain the business district's unique status in the city. The project will be Mumbai's first underground intersection.

Chitral hydro power tunnel completed

Chitral witnessed a new era in micro hydro development sector when local engineers made 240 metre long tunnel water channel to run a micro hydro power station producing 600 kilowatt electricity at Karimabad valley and work has been started on a 600 kilovolts hydro power house at Sewakht village of Shughoor valley.

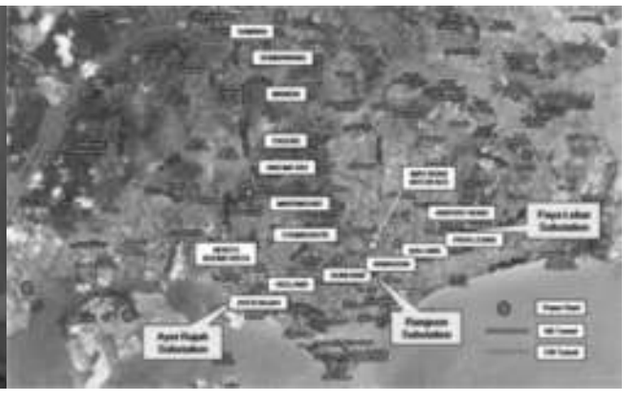
The tunnel, first of its nature constructed by local private entity, symbolises the commitment to development of Chitral people on self-help basis when people around the country react to the energy shortfall through protests and destruction.

The tunnel of 2 metres diameter was a joint venture of the local communities, GAP and Aga Khan Rural Support Programme (AKRSP), where GAP provided technical support to the project funded by the Pakistan Poverty Alleviation Fund (PPAF).

The micro hydro power Project, providing electricity to 9 villages of Karimabad valley of Lotkoh area, will be managed by the local community based power committee with the technical support of any energy company hired at local or national level.

The project will prove a milestone to the GAP commitment for larger projects and its efforts to work on the next generation energy solutions for sustainable livelihood and to make energy work for low income families and households. On Completion of 240 metre long tunnel a thanks giving day and a function was held at Sewakht village.

Regional programme Manager of AKRSP Engineer Sardar Ayub was chief guest on the occasion. Addressing the participants Eng. Sardar Ayub said.there are two tunnels240 and 35 metres long which were totally completed by local engineers without any casualty or loss. At first phase it will provide 500 kilovolts electricity to 11,000 people which will be augmentated to 600 kilovolts and will be completed within stipulated period of two years.



Singapore Power deep underground cable tunnel

Singapore Power is embarking on a $2 billion project from end-2012 to 2018 to build two cross-island transmission cable tunnels 60 metres underground to meet future demand.

The deep tunnels will facilitate faster and more efficient maintenance and replacement of cables, thereby reducing the frequency of road-digging works and thus minimising inconvenience to the public in the long run.

Singapore Power chief executive Wong Kim Yin said: "With the city's rapid growth and the corresponding increase in power demand, we are challenged to sustain this level of reliability and cost-effectiveness in achieving this performance.

"The deep cable tunnels will form the backbone of Singapore's power supply, serving future generations effectively, securely and with minimum inconvenience. It will translate to improved standards of living and performance for our residential, industrial and commercial consumers."

Two cross-island tunnels housing extra-high voltage electricity transmission cables will be built by Singapore Power (SP), thereby reducing the need for road-digging work to replace or maintain electricity cables.

The tunnels, which will be constructed 60 metres underground, will also help to relieve the congestion underground, which currently sees a myriad of uses such as sewer and gas pipes, underpasses and train lines.

Announcing the award of contracts to five construction companies yesterday, SP PowerGrid Managing Director Sim Kwong Mian said: "The reason why we are going so deep underground is because there is no more existing space to put in new cables ... if we want to replace the cables, we cannot dig up the old cables and put the new ones in — the existing cables still have to serve existing customers."

The S$2 billion Transmission Cable Tunnel Project — SP's largest infrastructure project to date — began construction at the end of 2012 and is expected to be completed by 2018.

When asked if consumers will have to bear the cost of the project, Mr Sim said it will be "marginal".

"As with all utility investments, the cost of this long-term investment will be recovered over many years and the impact to consumers will be marginal," he said.

SP PowerGrid's deputy managing director (punnel projects) Michael Chin also highlighted the cost-effectiveness of the tunnels — which have a lifespan of 120 years — as compared to the current method of directly burying transmission cables along public roads.

"Our cables' lifespan is about 30 years, so we can use this tunnel to house four generations of cables. If we go the conventional route, we would have to dig up the roads every 30 years. Working out the cost, this is actually more cost-effective," he said.

Located under major public roads, the 18.5 kilometres long North-South tunnel will stretch from Gambas in Sembawang to May Road near Whampoa, while the East-West tunnel is 16.5 kilometres long and will run from Ayer Rajah to Paya Lebar.

Up to 12 sets of transmission cables housed in the tunnels will serve to transmit electricity from power generation plants in Tuas, Jurong Island and Senoko.

LTA and SCDF test readiness in CTE tunnel

A chain collision involving three vehicles in a Central Expressway (CTE) tunnel during the evening peak hours caused toxic chemicals to spill, set a car on fire and resulted in many casualties — this was a scenario of an emergency exercise conducted by the Land Transport Authority (LTA) and the Singapore Civil Defence Force (SCDF), to test their readiness in managing a fire situation in the CTE tunnel.

About 200 officers took part in the joint exercise, which is carried out in road tunnels at least once a year. The last CTE tunnel exercise was held in June 2009.

In the situation of a fire in the road tunnels, emergency services such as the SCDF, Police and LTA Traffic Marshals, as well as Expressway Monitoring Advisory System (EMAS) crews are activated, and they will manage the fire, help motorists get out of the tunnel and divert traffic.

The operators at the LTA Operations Control Centre will also activate the tunnel ventilation system to push the smoke downstream out of the tunnel and raise the lighting of the tunnel to the maximum level of brightness. Any tunnel closure will also be announced by the LTA, and motorists will be advised to avoid the area through channels such as radio break-in, LTA traffic news, Twitter and EMAS signs.

Motorists were advised stay calm, turn off their vehicle engine and use the nearest escape staircase to get out of the tunnel. The LTA and the SCDF also warned motorists to not continue driving or reverse their vehicle if red crosses are lit on the overhead signs.

Singapore's Downtown Line

Robbins EPBs

In one of many deep shaft sites throughout Singapore, the first of six 6.65 metre diameter Robbins EPBs is ramping up for a mega construction project. The EPB is one of two that will excavate contract C927, running between Bedok Park and Bedok Reservoir, for contractor CMC di Ravenna of Italy. Four more Robbins EPBs will excavate contracts C925 and C937 for contractor GS Engineering & Construction of Korea.

The TBMs are part of a massive undertaking for Singapore's Downtown Line, Phase 3 (DTL3)—a stretch of 21 kilometres (13 miles) with 16 stations utilising 29 TBMs. Running almost parallel to the East West Line (EWL) of the metro, the DTL3 will provide a convenient transport link to the Central Business District and Marina Bay areas of Singapore.

The 62 tonne cutter head for the first of the two machines was lowered in August 2012 and the TBM began excavation in September 2012. "Assembling the machine was a challenge due to the small shaft opening. This required assembling the shield in smaller sections than usual, and required the use of a purpose-built lifting adaptor to lower the cutterhead support and forward shield separately," said Mark Passey, Robbins Site Manager. The cutterhead was then lowered through a 14 metre opening through the shaft cross bracing. The small launch area required shunting of components forward and backward on the launch cradle using two 100 tonne hydraulic jacks.

The two Robbins EPBs for the C927 contract will bore parallel 1.35 kilometre tunnels through alluvium consisting of cemented sandstone and beach rock. Each of the EPBs was designed with mixed ground cutterheads and cutting tools interchangeable with disc cutters. Flexible additive systems are capable of injecting foam, polymer, bentonite, or grout depending on the conditions. A probe drill on each of the machines is capable of drilling through the face and around the periphery of the shield, enabling quick and efficient excavation if any changeable ground conditions are encountered.

Alpine TBMs

Alpine Construction Co announced in September 2012 that it had completed the first of six tunnels it is building for Singapore's Downtown Line metro line under a 400m contract.

Boring of the 6·6 metre diameter tunnel between Tan Kah Kee and Sixth Avenue stations reached a rate of 93 metres/week, which the Austrian company said was 'a considerable speed considering the difficult soil conditions.'

Alpine has five TBMs and employees from 17 countries working on the Downtown Line project.

The entire Downtown Line including phases 1 and 2, for Singapore's Land Transportation Authority (LTA), will consist of 42 kilometres of new track with 34 stations. Once complete in 2017, the DTL is estimated to serve half a million commuters daily.

The 62 tonne cutter head for the first of the two machines was lowered in August 2012 and the TBM began excavation in September 2012.

Undersea tunnel for Singapore-Malaysia link

An undersea tunnel would be the most feasible option for the Rapid Transit System (RTS) between Malaysia and Singapore, according to the Iskandar Regional Development Authority (IRDA). However, the final decision will still depend on the governments of both countries- whether the RTS will include a bridge or an undersea tunnel across the Johor Straits, said Datuk Ismail Ibrahim, Chief Executive at IRDA, in a report by Bernama. "From initial indicators, Iskandar Malaysia feels the undersea tunnel is most feasible but it is up to both governments to find the most suitable route."

He explained that if the RTS will be outfitted with an undersea tunnel, other vehicles should also be able to use it and not just the rail transportation. Moreover, both countries have engaged consultants to conduct feasibility studies for the construction of the RTS, noted Ismail, adding that initial works are progressing efficiently and are expected to be completed next year. "After that, either in 2014 or the latest by 2015, we will be able to begin construction of the RTS." The RTS will not only connect Johor Bahru and Singapore, it also aims to create a comprehensive transport network for the entire Iskandar region.

Furthermore, the project's cost will be determined when both countries decide on the routes of the transportation system and after the completion of the feasibility studies, added Ismail.

Road tunnel under the Kolok river

A Thai envoy has travelled to the Malaysian border state of Kelantan to seek approval from the Sultan for the construction of a road tunnel under the Kolok river to link Narathiwat province and northern Malaysia. They are seeking his permission to construct an underwater tunnel linking the the south-eastern coastal district of Tak Bai in Narathiwat, Thailand, and Pengkalan Kubor in Kelantan, Malaysia.

Tak Bai district chief Somsak Sithiworakarn said the proposed 400 metre tunnel has been under discussion for years, but planning has never gone any further until now. The Thai government has agreed to shoulder the construction cost, estimated at 1.5 billion baht, as a gift to the sultan and the people of Kelantan, he said. When completed the tunnel would ease the problems faced by people on both sides of the border who are currently crossing the border river on boats and ferries. There is a bridge over the river from Sungai Kolok, further inland.

Pak-Korea deals for tunnel project

Pakistan and South Korea recently inked two agreements for the Malakand Tunnel Construction Project and for development of water resources infrastructure including dams. The agreement on Malakand Tunnel Construction Project was signed during meeting of President Asif Ali Zardari with Kim Yong-Hwan, Chairman Export Import Bank of Korea. Under the Malakand Tunnel Loan Agreement, an amount of $78 million will be provided for the project. The Korea Exim Bank is an official export credit agency providing comprehensive export credit and guarantee programmes to support Korean enterprises in conducting overseas business.

Malakand tunnel will provide a short route not only to people of Dir, Malakand and Swat and adjacent localities but would also be an easy access to central Asian states, providing the market access to the country for its products. Malakand Pass lies between Dargai-Batkhela and is situated at an altitude of 470 metres and 663 metres, respectively.

The South Korean government pledged the $78 million funding through the Economic Development Co-operation Fund (EDCF) for the construction of Malakand Tunnel project in Khyber Pakhtunkhwa province. The 9.7 kilometre project also includes approach roads on both sides of the tunnel and three bridges.

The initial feasibility study of the tunnel has already been completed by South Korean consultants in collaboration with National Highway Authority Pakistan, which is also the Project executing agency.

Under the MoU both the sides will work for sustainable water and power sector development and co-operate in development of water resources infrastructure, including dams, hydropower, flood control and canals. Both the sides will also exchange technical expertise, have training of engineers, technicians and conduct a study on operation and management of dams, hydropower, hydrology and sedimentation.

Jakarta Governor Joko Widodo inspects tunnels in Jakarta after heavy floods inundated some low-lying sections of the city.

Tunnel plan aims to end Jakarta floods

The Jakarta administration is planning to build a deep water tunnel to help the city cope with its seasonal flood problem. Jakarta Governor Joko Widodo said that the tunnel will be built from Cawang in East Jakarta, along Jalan MT Haryono, up to Pluit in North Jakarta.

Jokowi said that he estimated that the deep tunnel project is estimated to need some Rp 16 trillion ($1.66 billion), which will come from the city budget and the private sector. He estimated that the project will take four to five years to complete.

The drainage system on Jalan Thamrin was made more than 40 years ago. "This was made in 1970 and it was in accordance with the rain intensity at the time, which was not as high as it is today," said Jakarta Public Works Agency head Ery Basworo.Heavy rains in Jakarta often causes flooding and traffic to halt traffic in some parts of the city, now the Jakarta administration will kill two birds with one stone by installing a multipurpose tunnel to help alleviate flooding as well as traffic woes.

Agus Subardono, who heads the city's land zoning office, said that besides channeling flood water, the tunnel would also accommodate roads for traffic and utility piping. "The initial idea was to place it on the Ciliwung river [going] up to the West Flood Canal, but because it would involve too many bends, it was finally decided to be built under the road," Agus said on the sidelines of a presentation on the project at City Hall.

He added that the deep tunnel, with a diameter of 16 metres, will be built at a depth of between 40 to 60 metres and will consist of three channels. The upper two channels would be for traffic, while the last one would be used to transmit water and the utility piping. However, Agus noted that the road inside the tunnel would not go through the entire length, but only part of it. Only about 10 kilometres of the multipurpose deep tunnel will be for roads, and the rest would be for water catchment, he said, adding that the road portion would be from MT Haryono in East Jakarta to Slipi in West Jakarta.

He revealed that the road would charge tolls, with inlets in the Gatot Subroto area to accommodate traffic coming from the Warung Buncit and Mampang areas, as well as Tomang and Slipi Jaya.

Phuket's Patong Tunnel project

On 13 September 2012 at Phuket City Hall, Deputy Governor of Phuket — DrSommai Preechasilp together with Mr Bararuzaman Abdullan and Mr. Kawin Loo of AVOS (MALASIA) SDN, held a meeting to discuss the island's proposed Patong tunnel and light rail projects. AVOS (MALASIA) SDN have already made proposal regarding the construction of both projects.

Mr Bararuzaman Abdullan revealed the plan for the Patong tunnel. This would feature a 4 or 6 lane elevated road starting from the 4029 intersection in Kathu and lead to Patong beach via a double tunnel through the Nakerd Mountain. It is believed the tunnel length from Patong to Kathu will be 1,581 metres, and from Kathu to Patong 1,613 metres. The total length, including the elevated roads, will be 3.08 kilometres.

The tunnel project is being proposed as a way of making the Kathu to Patong Beach journey shorter and less dangerous that the present route, and is currently in the environmental impact investigation stage.

Metro collapses in China

Five workers were killed and 18 others injured after a platform collapsed in a parking lot being built to support a metro line in Shanghai on 31 December 2012. Another three workers were trapped in a collapsed tunnel of a metro line under construction in the southern Chinese city of Nanning, and were rescued on the evening of 2 January, although two workers died and another was injured in the incident.

The accident happened earlier that afternoon when three workers were working in a tunnel section under Minzu Avenue, rescuers said. The workers were there for a project to move two sewage pipelines to make way for the new metro line. All three workers sustained injuries and were sent to hospital.

The Shanghai Metro has become one of the fastest-growing rapid transit systems in the world, with several lines still under construction. During construction of Line 4 in 2003, part of the tunnel that was under construction close to the Huangpu River collapsed causing a six-storey building to collapse, and several other buildings in the neighbourhood had to be evacuated.

Nanning is close to the Vietnam border and by Chinese standards is only a small city with only 6.5 million people, and construction on its subway system began in 2009. A total of 6 metro lines are planned. Line 1 commenced on 29 December 2011, and is expected to be completed in 2016 with a length of 32.1 kilometres and 25 stations.

Li Yingming conducting an inspection on 30 October 2012 at the Huangtaishan Tunnel.

Tunnel guardian still smiling after 8 years

Li Yingming, 42, a patrol worker for the Wuhu Track Division of the Shanghai Railway Bureau has spent 8 years working in a tunnel on the Anhui to Jiangxi provincial railway.

The 660 metre long Huangtaishan Tunnel is situated in the mountains and an average of 40 trains pass through the tunnel within one day. Due to the complex geographical conditions of the surrounding environment, Li and his workmates keep the tunnel clear and ensure the security of passing trains.

"Sometimes, I feel lonely in the mountains, and maybe the passengers on board won't notice a worker that waves a yellow signal flag when the train rockets through the tunnel, but I will always keep a smile. The whistles from every safely passed train are my workmates' and my best consolation," said Li.

Li Yingming guides a passing train by waving a yellow flag on 30 October 2012 at the entrance of the Huangtaishan Tunnel of the Anhui to Jiangxi provincial railway.

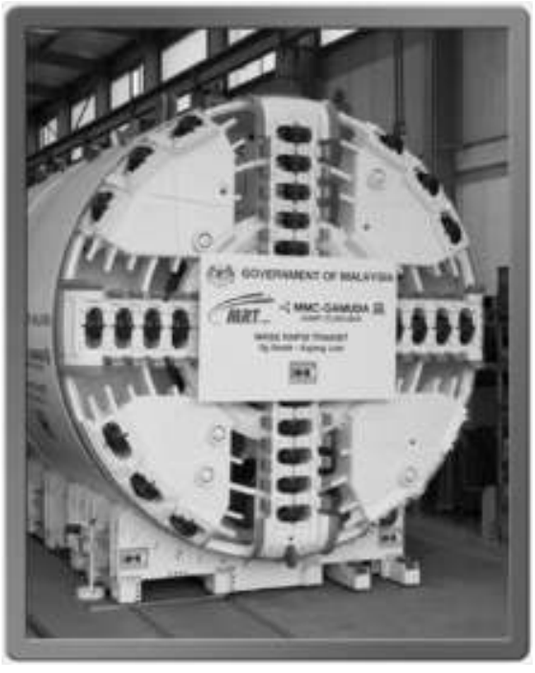
Maxwell Geosystems announces major project win in KL

Maxwell Geosystems has announced that it has been appointed by MMC GAMUDA to provide the Instrumentation Data Management System (IDMS) for the underground portion of the King Valley MRT (KVMRT) in Kuala Lumpur.

The KVMRT will be integrated with the existing LRT, Monorail, KTM Komuter and bus network to improve the city's public transport system. The first phase of the project is the Sungai Buloh-Kajang Line (SBK) with a 9.3 kilometre underground alignment between Semantan North Portal to Maluri South Portal. This includes seven station boxes, between 25 to 45 metres deep, 3 emergency escape shafts and 2 intervention shafts.

The alignment traverses challenging geological formations including extreme karstic limestone with caves and cavities beneath a cover of soft soil, presenting very irregular tunnelling conditions. The underground portion will pass through the densley developed inner city and heritage buildings of Kuala Lumpur, and a robust approach to geotechnical and structural risk modelling during tunnelling is essential to ensure the stability of the urban environment.

Maxwekk Geosystems proprietary MISSION OS will integrate the construction and TBM data with the instrumentation data, providing a shared real time "cause and effect" analysis resource. According to MMC Gamuda. Maxwell Geosystem's excellent track record on Asian projects was a key to winning the award, together with their ability to cover all aspects of the brief and their commitment to delivering the service in a collaborative manner.



MTR sought to tunnel on mainland China

Chinese cities banking on public transit projects to generate economic growth are turning a hopeful eye toward publicly traded subway contractor Mass Transit Railway Corp.

What's unclear, though, is whether Hong Kong-listed MTR is willing, or even allowed to, work with second- and third-tier governments in cities where urban mass transit generally means buses.

Founded in 1975, MTR operates more than 200 kilometres of rail lines in Hong Kong. Its mainland affiliate Beijing MTR Corp, the first urban transit operator of its kind in China, was launched in 2006 with investors Beijing Infrastructure Investment Co. Ltd. (2%), Beijing Capital Group (49%) and MTR (49%).

The Hong Kong entity has been working with the mainland municipal government in nearby Shenzhen since 2002, when the city hired MTR to build and operate its metro system's Longhua Line downtown.

The company's mainland affiliate has co-operated for subway lines in Beijing, and has so far unsuccessfully tried to expand into Shenyang and Wuhan.

Local governments have looked closely at a co-operation model MTR used successfully in Shenzhen and Beijing, said a source who works for passenger train manufacturer CSR Corp. in Beijing.

Yi Min, MTR's chief executive, told Caixin he's optimistic about prospects for cooperating in the future with more mainland cities, which he said could build transit systems based on a comprehensive development model his company used successfully in Hong Kong.

MTR complements rail projects with real estate developments, such as apartments and shopping malls adjacent to subway stations. The company thus counts on revenues from property leasing and management, as well as subway fares and on-train advertising.

MTR's interest in working with other cities around the country may thus hinge on whether the company can expect enough non-fare revenues — from property management, advertising or other sources — to make the business work.

Founded in 1975, MTR operates more than 200 kilometres of rail lines in Hong Kong.

Shanxi rail tunnel explosion cover up

The Associated Press in Beijing reports that a subsidiary of a state-owned railway company covered up a tunnel explosion that killed eight people and injured five on 25 December 2012. The State Administration of Work Safety says a subsidiary of state-owned China Railway Tunnel Group concealed the explosion in northern Shanxi province in a railway tunnel under construction, but that it was reported on line by some of the workers.

The official Xinhua news agency says an initial investigation found that the accident was caused by illegal blasting operations and concealed by the construction project manager. The work safety administration says authorities will crack down on the concealment of fatal accidents and promised severe punishments.

The blast, came to light 10 days later thanks to Internet users. Four company officials have been arrested. It is reported that managers of the company paid off witnesses and survivors in an attempt to conceal the fatal tunnel explosion.

The blast happened around 3pm at the No. 1 slope mine of the Luliangshan Tunnel project for the railway, but instead of sending in rescuers, managers tried to conceal the accident, witnesses said.

"No one went into the mine to save people. I begged them and only four people went in, who later saved three others in half an hour," said a family member of a victim surnamed Liu.

Liu said the rescue team at the site was not equipped with proper gear and had to put wet towels on their mouths. "There were no oxygen masks or searchlights," Liu added.

Bodies of the victims were sent to other provinces. Each worker was paid 20,000 yuan (US$3,212) by the company, a villager said. A family of one of the victims was given 800,000 yuan in compensation and asked to leave. To cover up the accident, victims' bodies were cremated in Henan Province 360 kilometres away, while the injured were also taken to Henan for treatment.

Abu Dhabi completes longest traffic tunnel

Abu Dhabi completed the region's longest traffic tunnel that stretches more than 3 kilometres in November 2012. Work on the project, which cost more than Dh5 billion, began nearly 5 years ago as one of the largest road construction ventures ever to be carried out in the UAE. The tunnel had been due to be completed at the end of 2010 but was delayed because of technical and topographical snags, according to the Abu Dhabi Municipality which is carrying out the project on the capital's eastern flank.

South Korea's Samsung Construction carried out the project, which will also link the mainland to the nearby Reem Island, where at least 100,000 inhabitants will live. More than 2,000 workers were involved in the construction of the 3.5 kilometre tunnel, which starts from the eastern entrance of Abu Dhabi city and runs under Alsalam street towards Port Zayed on the western tip of the capital.

Officials said the tunnel is part of a long-term blueprint by Abu Dhabi to expand its inhabited areas and road networks to cope with a sharp rise in the population, which officials expect to nearly triple in the next 20 years. A municipality statement said the road could have a capacity of 12,000 cars per hour in both directions once it becomes fully operational.

Herrenknecht opens service branch in Abu Dhabi

Herrenknecht AG responds to the high demand for micromachines and comprehensive services in the Gulf region by opening a full-service branch in Abu Dhabi in November 2012. The new company, Herrenknecht Tunnelling Systems LLC, offers top level machine overhauls, Field Service and supply of spare parts.

Comprehensive infrastructural works are planned and being realised in Abu Dhabi to support the growth of the city's population from 621,000 inhabitants in 2012, to over 3 million by the year 2030. Abu Dhabi's Strategic Tunnel Enhancement Program (STEP) is one of these. It aims to restructure the city's sewage network by building extensive tunnel networks. New supply networks, the Link Tunnels, will connect the existing sewage system with the new main collector, the so-called Deep Tunnel sewer. This tunnel runs from Abu Dhabi's city center to a newly planned water treatment facility in the municipality of Al-Wathba, 42 kilometres to the southeast of the city, closing the desert city's sewage circuit and supplying up to 15 cubic mtres per second of treated water for irrigation.

The Herrenknecht Group is involved in the project with a total of 14 tunnel boring machines for the Link Tunnels and the Deep Tunnel sewer. Herrenknecht AG delivered 5 EPB machines with large diameters (3 x 6.31 metres, 2 x 6.95 metres) to Impregilo SpA, the contractor for the construction lots T-02 and T-03 of the Deep Tunnel sewer. These machines excavated tunnels with an overall length of 25 kilometres at depths of down to 80 metrees. Last breakthrough was reached on 18 December 2012. From January 2013 onwards, 9 Herrenknecht Micromachines (8 x AVN, diameter 0.96 metre — 3.37 metres and 1 x EPB, diameter 3.72 metres) will be employed at the almost 50 kilometre long Link Tunnels. Commodore Cement Industries LLC has produced more than 100,000 lining segments for the Deep Tunnel. Herrenknecht Formwork Technology GmbH planned the entire lining segment production plant, commissioned the plant and delivered 162 moulds as well as a data recording and documentation system (SDS) for lining segment production.

Tunnels to stop flood chaos in Malta

According to Resources Minister George Pullicino about 700,000 cubic metres of rainwater could be harvested and recycled through the Government's national flood relief project. The capacity of reservoirs will triple from 300,000 cubic metres as rainwater will pass through huge tunnels and culverts being built.

A soak-away reservoir of about 10,000 cubic metres of water is being built in Gzira. It will collect the rainwater passing through Wied Għollieqa and from the storm-water tunnels. Soak-away reservoirs are designed to allow water to percolate into aquifers, providing them with some much-needed replenishment. The water in the Gzira reservoir would eventually trickle down into the water table, Mr Pullicino explained.

The €56 million project involves the construction of 17 kilometres of underground tunnels, canals, bridges and repairing of culverts and other rainwater infrastructure. These will channel storm water away from flood-prone zones.

Excavation works are well under way on the 11km underground tunnel from Attard to Ta' Xbiex, having a diameter that varies between 3.6 and 6 metres.

TBMs launched in Austria's Koralm tunnel

Two 9.93 metre diameter TBMs have begun boring the central section of the 32.5 kilometre Koralm tunnel, the centrepiece of the new Koralm line between Graz and Klagenfurt in southern Austria. The first 3 kilometres from the eastern portal of the two single-track bores have been built using conventional tunnelling techniques.

Contractors have faced a particular challenge in gaining access to the underground construction area.

Establishing a construction base near the eastern portal was ruled out for environmental reasons, so the only viable solution was to sink a 60 metre deep supply shaft at Liebenfeld south of Deutschlandsberg. This allowed equipment to be lowered into a cavern where the TBMs were assembled in-situ.

The supply shaft is served by a spur from the Graz-Köflach Railway (GKB) Lieboch — Wies-Eibiswald line, which is being used to deliver construction materials to the site and remove spoil from the tunnel.

The project is due to be completed in 2020.

The first 3 kilometres from the eastern portal of the two single-track bores have been built using conventional tunnelling techniques.

SWISS SAFETY TUNNEL

The Milchbuck Tunnel was built in 1985 and is one of the most important traffic arteries in Zurich. It is numbered among the most frequently used single-bore tunnels in Switzerland. Since 2003 this 1.9 kilometre long tunnel has been upgraded in terms of the latest safety technology. So far the energy supply has been renewed as well as the lighting, tunnel ventilation and traffic guidance system. Furthermore it has been equipped with smoke detectors and video monitoring. The most recent work is the construction of a safety tunnel running parallel to the main tunnel with five cross passages. The construction is being carried out by Marti Tunnelbau AG.

On 4 December 2012, a steadfast Robbins TBM made its final breakthrough. The Milchbuck Safety Tunnel required two methods of excavation due to a split in geology—1,000 metres of TBM tunnel bored through molasse rock of about 80 MPa UCS, and 400 metres dug conventionally in unconsolidated rock, mainly Moraine. The machine completed tunnelling in March 2012 but was stopped and awaited the completion of the conventionally excavated tunnel section.

The TBM breakthrough marks the completion of the fourth tunnel for the 4.15 metre diameter Robbins Main Beam machine, which underwent major refurbishment in 2002. Robbins carried out the machine's latest rebuild as well, which included a diameter change from 4.4 to 4.15 metres as well as new cutterhead structures including muck buckets and grill bars. Back-up refurbishment and design was done by the contractor.

The TBM successfully excavated through 400 metres of compact rock and 600 metres of fractured zones with over-break where 360 degree shotcrete was applied. The design allowed for a 20 centimetre thick wet application using two shotcrete robots for the full length of the tunnel.

In order to excavate the conventionally excavated section in difficult ground, crews created a reinforced crown of jet grout. Beneath the jet grout umbrella, crews mined meter by meter with a tunnel excavator, applying a lining of steel arches and shotcrete.

Neuhof underwater road tunnel

The tunnel is part of the A66 Federal Motorway, which leads from the Hessian capital of Wiesbaden to the Fulda motorway junction via Frankfurt. Construction of the tunnel includes around 15,000 cubic metres of underwater concrete placement.

Cemex is part of a consortium supplying ready-mix concrete for the project. A continuous, uninterrupted flow of materials is needed while maintaining uniform quality of concrete and protecting against desolving. Strict quality control and tailor-made delivery methods are necessary to complete the task. Around 2,500 cubic metres of concrete is placed at a time with the aid of divers and an output per hour is 100-120 cubic metres by using large pumps measuring up to 63 metres in height in a pump cascade supply.

The water of the nearby Fliede stream and the ground water is pressed into the foundation pit, which is why underwater concrete is required to build the footwall. Pumping out the pit is not possible, because this would cause the ground water level to sink and considerable damage would occur. The divers are responsible for two tasks: they level the height of the concrete and remove mud from the foundation pit at the same time.

High-tech premiere for TGV Tunnel

Two months earlier than planned, tunnel boring machine Charlotte reached the west side of the Vosges Mountains, concluding excavation for the first tube of the Tunnel de Saverne. A newly developed high-tech machine from Herrenknecht is being used, which can be converted inside the tunnel and adjusted for different soil conditions. The twin-tube rail tunnel is part of the section on the TGV Paris-Strasbourg line currently being expanded for train speeds of up to 320 kilometres per hour.

The TBM began excavation of the nearly four kilometre long north tube on the eastern side of the Vosges at the launch portal near Ernolsheim lès Saverne in November 2011. Two months ahead of schedule it was able to complete excavation of the first tube on the west side of the Vosges in late June 2012. During the seven months of tunnelling the site teams achieved daily best performances of up to 46 metres and weekly best performances of up to 250 metres.

The Schwanau engineers adapted the Herrenknecht tunnel boring machine known as "Charlotte" (open mode convertible EPB Shield S-670, 10,010 millimetre diameter) to the geological conditions in the project in such a way that it could handle excavation in two different soil types. For the first 200 metres of the northern tunnel it worked through unconsolidated rock (a mixture of sandstone and shell limestone) in the closed EPB (Earth Pressure Balance Shield) mode. In accordance with the prevailing hard rock (red sandstone) that followed, the rest of the advance was continued in open mode. For switching between modes all that is needed are some adjustments at the cutting wheel. The conveyor belt and the screw conveyor remain installed on the machine in both modes. The Saverne project is the first time a Herrenknecht TBM with a convertible EPB shield has been used that can also handle the open hard rock mode with belt conveyor discharge. After the breakthrough the TBM was disassembled and the individual components transported back to the launch platform at Ernolsheim lès Saverne to begin excavation of the southern tube in October 2012.

Bosphorus Strait Tunnel

The European Bank for Reconstruction & Development (EBRD) has approved a US$150 million (€115 million) loan to support construction of a tunnel in Turkey that will link Europe and Asia.

The 5.4 kilometre Eurasia Tunnel will be built 25 metres under the Bosphorus Strait, which divides the Turkish city of Istanbul between two continents — separating Asian Turkey from European Turkey.

Designed to improve traffic management in Istanbul, the Eurasia Tunnel is planned for completion in 2017 and will also connect on both the European and Turkish sides to wider road networks. The overall length of the project is 14.6 kilometres.

The concession contract for the Eurasia Tunnel, also known as the Istanbul Strait Road Tube Crossing, will be built by ATAS — a Turkey-Korea joint venture consortium which was selected trough an international tender by the Turkish government to build and operate the tunnel. The investment partners in ATAS are Turkish contractor Yapi Merkezi and Korea's SK Engineering & Construction.

LONDON CABLE TUNNEL

Breakthrough has been achieved on the second stage of a cable tunnel scheme in London which, when complete, will stretch for 6.1 kilometres between New Cross in southeast London, and Finsbury Market in the City, via Whitechapel in the East End.

With only millimetres to spare, the 2.6 metre diameter TBM broke into an underground chamber at the 1.1 kilometre point which is seen as a key milestone in the construction of the 2.6 kilometre stretch between Whitechapel and Finsbury Market. UK-based Tunnel Engineering Services (TES) supplied the TBM which is an open-faced back-actor with digging arm. It will line the tunnel with a total of 2,815 concrete rings.

Tunnelling began last May beneath Whitechapel and is expected to reach Finsbury Market in spring 2013. Typical advance rates have been in the region of around 50 metres per week.

Project manager Bill Francis, said: "The chamber diameter was 50 millimetres bigger than the machine so the engineering had to be incredibly precise. We carry out very accurate surveying for this kind of project and it avoids enormous disruption along the route."

The project will provide London with an easy to maintain underground electricity 'super-highway' and help ensure the population is kept connected to safe and reliable electricity supplies.

The TBM is digging 19 kilometres of the 32kilometre London Power Tunnels project. A second TBM, Cleopatra, is digging the other 13 kilometres of the route and is currently approximately 2.5 kilometres from the launch site in Haringey. The London Power Tunnels project is due for completion in 2018.

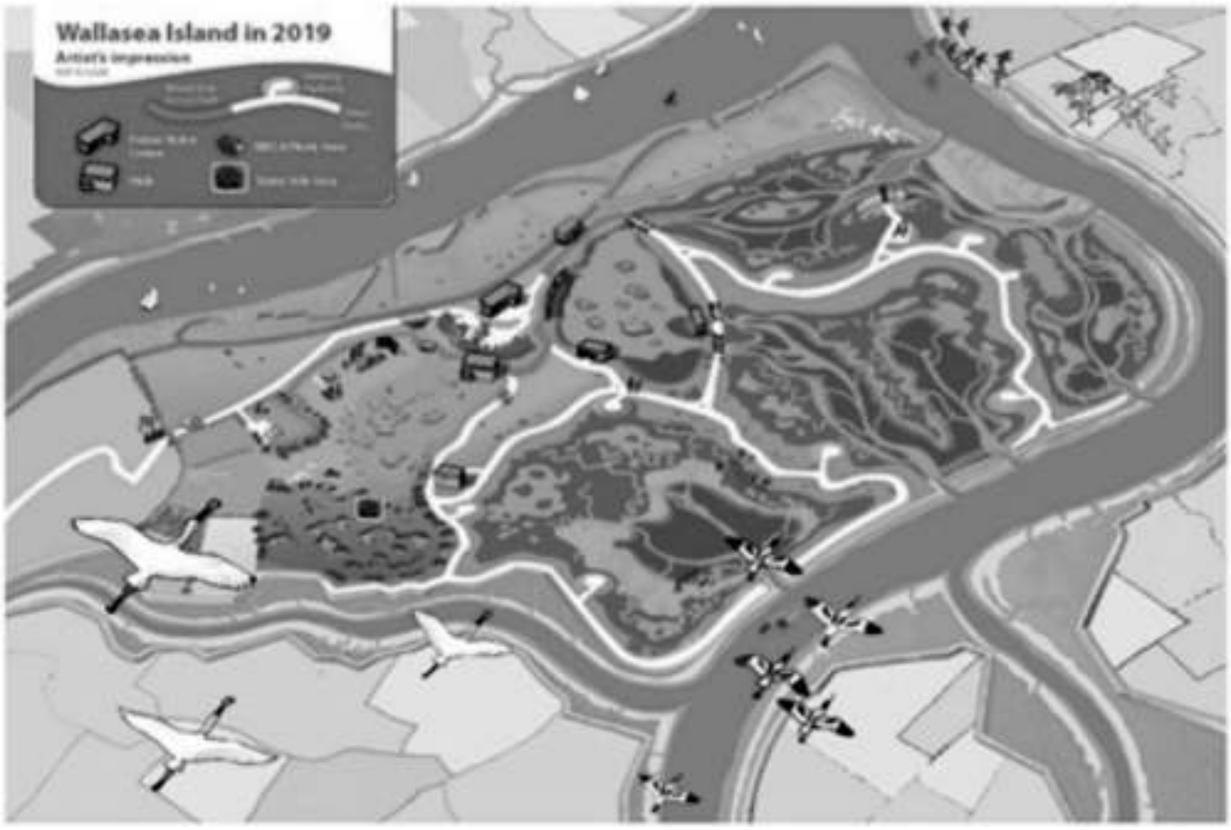
In October 2012 J Murphy & Sons achieved a high score for its work on the Willesden to Taylors Lane Deep Cable Tunnel project in northwest London as part of the Considerate Constructors Scheme, a scheme reviewing environmental and social impacts. A 'performance beyond compliance' score was given to and as a result, the site is now claimed to rank within the top 10 per cent of high-performing UK construction sites.

The Considerate Constructors Scheme is a national initiative set up by the construction industry to encourage best practice beyond statutory requirements and protect the general public, employees and the environment. It looks at various criteria, including project site environment, local impact, appearance, community relations, safety, and operative occupational health and safety.

Mammoth's tusk in German train tunnel

Tunnellers working on the underground network in the western city of Duesseldorf uncovered a 34 kilogram woolly mammoth tusk more than 10,000 years old.

Excavation work was stopped immediately while the 1.20 metre long tusk was gently removed and taken away for scientific study. The tusk was the only part of the animal found during the dig some 12 metres below the surface. Woolly mammoths died out in the region around present-day Germany some 10,000 years ago.



CrossRail tunnel spoil to create nature reserve

Spoil from excavating CrossRail's tunnels beneath London, UK, is being used to transform an island landscape from farmland into a 670 hectare wetland. The first scoops of TBM excavated spoil from beneath London were delivered to the Essex coast recently, ready to be used in the transformation of Wallasea Island's dead-level intensive farmland. The end result will be Europe's biggest man-made nature reserve, to be created from around five million tonnes of spoil.

The project aims to create a labyrinth of mudflats, saltmarshes and lagoons last seen on the site 400 years ago. It is hoped the newly created landscape will attract breeds of bird that have long-vanished from the English countryside, such as spoonbills and Kentish plovers, not to mention increasing flocks of other birds.

Hopes are also high for saltwater fish such as bass, herring and flounder to use the wetland as a nursery, thereby helping the small, local seal colony; plants such as samphire, sea lavender and sea aster are also expected to thrive.

The end result will be Europe's biggest man-made nature reserve, to be created from around five million tonnes of spoil.

It is thought that Wallasea Island may first have been reclaimed from the sea centuries ago by Dutch engineers, but was levelled 20 years ago to allow the cultivation of cereals. Surrounded by tall, grassy levees, it is now 2 metres below sea level at high tide, and every year there is a one in five risk of serious flooding.

"It would have been enormously expensive to keep up the flood defences, with a real risk of major disaster," said environment secretary Owen Paterson, and added that utilising the vast quantity of soil from the US$24 billion Crossrail project to raise Wallasea Island by 2 metres was a win-win situation.

"What it shows is that you should not be frightened of big infrastructure projects on environmental grounds. You can turn them to your advantage."

Helsinki plans new metro

Helsinki, Finland, is planning a new underground rail line to serve the city centre. At 7.2 kilometres long, the proposed ring line will have just three stations and connect with other rail hubs around the Töölö Bay area.

Preliminary plans see the metro line starting from a location south of the Pasila transport hub. Of the 7.2 kilometre line length, 6 kilometres will be underground, served by two parallel rail tunnels, with cross passages at 200 metre intervals. The three stations, each of which will have up to three entrances, will be located in Hakaniemi, the city centre, and Töölö.

Dubbed the Pisara line due to its teardrop shape, the proposed line is intended to ease congestion in the north of the city. It will provide more frequent local trains and ease congestion from the main railway station northwards, benefitting rail transport on a national level.

Helsinki City Council will make a final decision on the plan in 2014.

Power tunnel under Toronto

Most talk of tunnel boring in Toronto prompts images of future subway lines, but Hydro One and Toronto Hydro have introduced their own tunnel-boring machine to put a new passage in midtown Toronto to upgrade transmission cables.

The existing transmission cables in the mid-town power corridor were laid in the 1950s and need to be upgraded before they start failing and causing outages. Moreover, development in the area means more power is needed.

The 2.4 kilometre tunnel is being dug about 60 metres underground, beginning at the Rosehill Pumping Station on Mount Pleasant Road by Carstowe Road. Boring will extend east to Bayview Avenue, and then the machine will head west to stop at Yonge Street and Birch Avenue. Once the tunnel is lined with concrete, new transmission cables will be laid to serve current customers as well as 32,500 new homes. Three new circuits will also be installed. The tunnel boring will take about a year to complete.

Many of the cables and the two circuits that are already underground are hard to reach, hence the new tunnel. "We would have to disturb a lot of neighbourhoods and communities. Some cables are directly underneath people's houses," said Mr Butorsky. Hydro One spokeswoman Denise Jamal later confirmed that cables do not actually run underneath people's houses, but that neighbourhoods would be affected if work was being done above ground. Mr Butorsky said construction of the new tunnel would not affect traffic above ground. It will have several accessible shafts so future upgrades and maintenance will be easier. The power source for existing customers in this corridor will be switched to the new cables once they are in place.

The total cost of the project, which started with public consultations and designs in 2008, is pegged at $115.85 million. Toronto Hydro is investing 40 per cent — approximately $46 million over the years. Hydro One is covering the rest.

Texan Water Line deploys multiple machines

Deep below Austin, Texas, USA, the sprawling Jollyville Transmission Main is set to dramatically increase capacity of the city's main drinking water reservoir. The 10.5 kilometre waterway is being constructed using three TBMs, including two Robbins machines, up to 107 metres below the city. The Southland/Mole JV is building the 2.1 metre finished diameter pipeline below residential areas and the protected Balcones Canyonlands Preserve.

Three TBMs will excavate the pipeline, with one contractor-owned machine having completed its 1.4 kilometre section in mid-2012. Robbins supplied an additional 3.25 metre) Main Beam TBM, and refurbished a 3.0 metre) Double Shield TBM in its Solon, Ohio, USA manufacturing facility. Both machines were launched in August 2012 from deep shaft sites.

"We needed the Robbins High Performance Main Beam TBM for the longest bore, which is on the critical path for the project. It's built to beat our 230 day schedule, and for even tougher conditions than are foreseen here," said Tim Winn, Director of Southland Contracting.

Conditions along the way are expected to consist of uniform limestone and dolomite rock. Although karst features are present throughout the formation, the depth of the tunnel should circumvent these features. Other obstacles are associated with the protected wildlife area—endangered cave-dwelling invertebrates including six species of arachnids and insects are present in and around the karsts. Because of this, no probe grouting can be performed due to the risk of seepage into the water features. "We don't expect any features that will need significant support. Rock bolts will be the predominant form of support, and there may be some areas requiring wire mesh. Anywhere there is a water feature, we will install a liner that will be grouted in place to seal those zones," said Winn.

The cutterhead lowering of a high-powered Robbins Main Beam TBM boring the Jollyville Transmission Main in Texas, USA.

The smaller size of the 3.25 metre (10.7 feet) Robbins Main Beam tunnel requires thorough logistical planning by the Southland/Mole JV.

Within a week of its launch in late August 2012, the Main Beam machine had advanced about 90 metres, and it is currently keeping up a strong pace, having bored ahead 760 metres).

The fast advance is a result of extensive planning, as logistics are often a limiting factor at small tunnel diameters: "We need to plan well in advance how ventilation and muck removal will work towards the end of tunnelling. Ventilation is the biggest issue. We have multiple trains in the tunnel at once, so the requirements for ventilation are significant.

Our second biggest problem is getting people and materials in and out, which takes quite a bit of time," said Winn. In the Main Beam tunnel, Southland has planned for two California switches and one shaft switch. An oversized vent duct and additional fans will help aerate the tunnel.

Once complete in 2013, the pipeline will transfer up to 190 million litres (50 million gallons) of treated water per day from Lake Travis. The tunnel, for the Austin Water Utility, will connect up with the new Water Treatment Plant 4 currently under construction—part of a larger scheme to provide increased water capacity for a projected 60 per cent increase in population over the next two decades.

Niagara Tunnel Project nearing completion

Ontario energy minister Chris Bentley will be in Niagara Falls for a ceremony commemorating the completion of the Niagara Tunnel Project. Ontario energy minister Chris Bentley was in town to mark the last pouring of concrete for the $1.6-billion project, which in 2013 will start carrying more water from the upper Niagara River to the Sir Adam Beck generating station. That will provide enough hydroelectricity to power 160,000 homes each year.

"This is a huge accomplishment for Ontario Power Generation, the workers and construction crews," said Bentley. "(The project will provide) a lot of additional, clean power and continue the great tradition of Niagara Falls and the Beck generating stations."

Over the coming months, workers will complete the tunnel grouting and begin removing lighting and service-water pipes.

Larger structures of steel at either end of the tunnel will also be removed so water can flow from the Niagara River through the tunnel leading to the Sir Adam Beck Generating Station.

About 300 people are employed on the project and at peak, the work force numbered 580.

The project was originally supposed to be completed at the end of 2009, but that date, along with the initial $1 billion cost figure went out the window when Big Becky, the world's largest hard rock tunnel boring machine, ran into tougher-than expected conditions along the 10 kilometre route.

Boring the tunnel wrapped up in May 2011, but work continued to line the 14.4 metre diameter walls with concrete. Ontario Power Generation, owned by the province, contracted Strabag AG to build the tunnel.

Earlier this year, OPG president Tom Mitchell said they will approach the Ontario Energy Board requesting an increase in hydro rates by about 50 cents per month, per household to pay for the project, which would raise the cost of electricity by about $6 per year.

The project is about $600 million more than originally anticipated.

NIAGARA TUNNEL PROJECT TIMELINE

2003: Premier Dalton McGuinty promises more electricity from Niagara River

2004: Ontario approves Niagara Tunnel Project

2006: McGuinty flips switch to start Big Becky

2009: Project behind schedule, over budget

2011: Big Becky breaks through.

2012: Concrete lining complete

2013: Water expected to start flowing

Jacobs wins BART construction management

Jacobs Engineering Group has received a US$20 million contract from San Francisco Bay Area Rapid Transit (BART) to provide construction management services on an on-call basis. These have been designed to support the agency's Capital Improvement Program and its delivery of design-bid-build, design-build, and procurement projects.

Jacobs said it will provide professional construction management services for five years, including resident, field and office engineering services; inspection services; constructability analysis, hazard analysis and safety certification; surveying; material testing; as well as noise and vibration monitoring and data analysis; cost and schedule management; coordination with other agencies; and claims management.

The BART network connects San Francisco with cities in the East Bay and suburbs in San Mateo County, operating five lines on 167 kilometre of track with 44 stations. It is considered the fifth busiest rapid transit system in the US.

Robbins Hard Rock TBM for Midwest Water Tunnel

On 27 November 2012 a 6.2 metre diameter Robbins hard rock cutterhead arrived in Indianapolis, Indiana, USA. The arrival at the staging site was timed with a ceremony that included the city's mayor and local officials, marking the assembly progress of the large Main Beam TBM. Once launched from a 76 metre deep shaft, the machine will embark on a 12.2 kilometre long wastewater tunnel for the Shea/ Kiewit JV.

The contractor-owned Robbins machine was refurbished and redesigned in Cleveland, Ohio and Mt Pleasant, Pennsylvania facilities following its most recent excavation at New York City's Second Avenue Subway.

Its latest rebuild was complex, according to Dave Girard, Senior Engineer for J.F. Shea Construction: "We retrofitted a machine built in 1976 with the latest technology — in particular, variable frequency drive motors." Other new components include the back-loading cutterhead with 19 inch disc cutters and rescue chamber.

Despite the complexities of the redesign, the machine is scheduled to be launched from a deep shaft in early 2013, proceeding towards the Belmont Wastewater Treatment Plant in what is expected to be competent limestone and dolomite rock. Robbins continuous conveyors, including a horizontal and vertical conveyor, will aid in muck removal on the long drive.

Once complete, the tunnel will be lined with un-reinforced concrete, making the finished diameter 5.5 metres). Cleaner water is the ultimate goal of the city's new Deep Rock Tunnel Connector (DRTC), along with four shorter tunnels that will be added on afterwards. The DRTC will convey up to 2.1 million cubic metres of combined sewer overflows daily to the Southport Advanced Water Treatment Plant. By 2025, the network of five tunnels will total over 40 kilometres, and will reduce wastewater overflow into the White River, Fall Creek, Pogues Run and Pleasant Run waterways by 95 per cent or more.

A Robbins Main Beam TBM is preparing to excavate the Indianapolis DRT for JV contractor Shea/Kiewit. The contractor-owned machine includes a cutterhead refurbished by Robbins, with 19 inch disc cutters.

Rio Subway

The State Government of Rio de Janeiro and the tunnelling contractor Rio Barra, have received the TBM to drill the underground tunnels of Subway Line 4 from Ipanema to Gávea.

Weighing 2,883 tons, this 120 metre long by 11.5 metres in diameter, the tunnel boring machine is expected to dig 1518 metres of tunnel per day, which is four times faster than the methods previously used in Rio de Janeiro. An unprecedented technology in Rio de Janeiro, it is the largest equipment ever used in construction projects in Brazil. It will be transported by ship in 19 containers and 92 other large loose pieces.

The Subway Line 4 will employ 270 people working exclusively to operate the tunnel-boring machine. Electrotechnical experts, mechanics, operators and supervisors will work in three shifts. Three Brazilian workers are receiving training in Germany, where the machine was built. Thirty experts will come from Germany to assist to operate and maintain the machine.

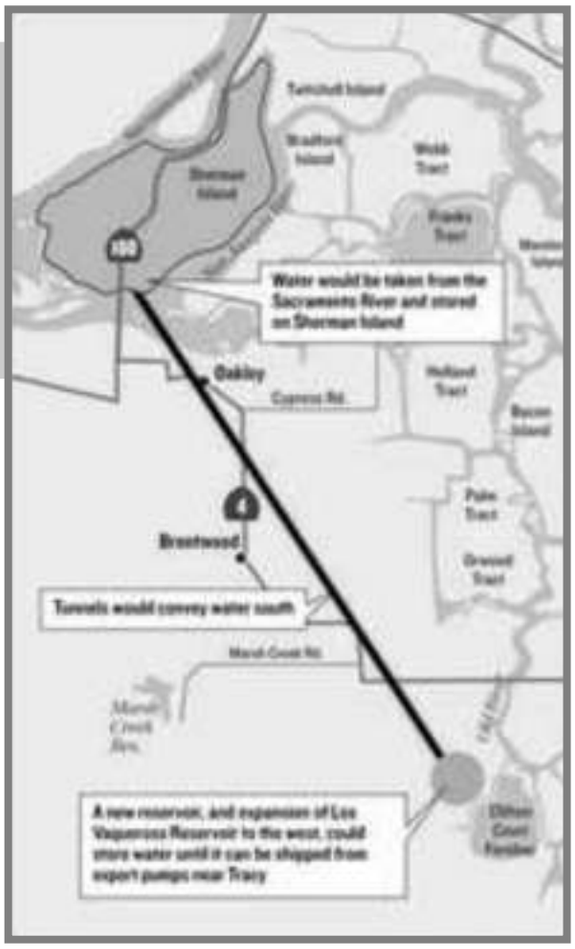
Subway Line 4 will benefit more than 300,000 people per day

The Subway Line 4 of Rio de Janeiro will carry, as of 2016, over 300,000 people per day and take 2,000 cars per hour from the streets around at peak times.

Construction works began in June 2010 in Barra da Tijuca and will be completed in December 2015, when the six stations (Nossa Senhora da Paz, Jardim de Alah, Antero de Quental, Gávea, São Conrado and Jardim Oceânico) will be opened. More than 3,000 metres of tunnels will be dug from Barra da Tijuca to Gávea. The new line, which is approximately 25 kilometre long, goes into operation in the second half of 2016, after a test phase.

To ensure system efficiency and passenger convenience, 17 trains will be purchased to operate Line 4. These will be capable of carrying more than 1 million passengers a day, while the estimated demand for Line 4 in 2016 is 300,000 users/day.

Australian engineer proposes cheaper alternative to Delta tunnel



An Australian-born engineer Robert Pyke says he's discovered a cheaper and less controversial alternative to Gov. Jerry Brown's twin tunnels plan and local officials want the State to take a close look. San Joaquin County supervisors Larry Ruhstaller and Ken Vogel have called on the State to give Pyke's plan the same consideration as the much-discussed twin tunnels concept.

Pyke, 70, came from Australia in 1969 and has worked as an independent engineer most of that time. Local officials plan to solicit support from Congressional representatives next month in Washington, D.C.

Both plans involve tunnels. But instead of taking the water from the Sacramento River in the north Delta, Pyke would move the intake west all the way to Sherman Island, toward Antioch. That would allow Sacramento River water to flow through the Delta before it's siphoned off the river. Opponents to the governor's plan believe diverting the water upstream will ruin the estuary.

Sherman Island would become a reservoir to store river water until it could be pumped into the tunnels, which would burrow south to the existing large export pumps near Tracy. A new reservoir would be built near those pumps, and Los Vaqueros Reservoir to the west would be expanded, allowing for more water storage before all that Delta water is sent to cities and farms as far away as San Diego.

Pyke would also build a canal linking the export aqueducts with the San Joaquin River, allowing some water to be sent back to the Delta and improving water quality for farmers there. All this could be done in conjunction with a separate proposal to bolster Delta levees, Pyke argues. While he provides no exact estimate, he believes it would be cheaper than the governor's $14 billion plan.

Pyke's plan isn't entirely new. He's been floating it informally for two years, and a proposal to study it passed out of one committee in the State Legislature before stalling. Only recently has Pyke published a more detailed description of his idea. He believes his solution can accommodate everyone's needs. The Delta gets its water, and the people get theirs.

The governor's plan — formally known as the Bay Delta Conservation Plan — will require officials to agree on how much water can safely be exported from the Delta, an agreement which Pyke believes will be hard to reach.

But the Metropolitan Water District of Southern California have some key concerns. Among them: Water quality is likely to be worse farther downstream, where Pyke proposes pulling the water out of the Sacramento River. Large levees would have to be built to protect the Sherman Island reservoir, which might cause water to seep through smaller levees on neighbouring islands.

Then there's the matter of fish. A spokeswoman for the State Department of Water Resources said a couple of options that contain elements of Pyke's plan have been considered, but his plan will not be analysed as a "discrete alternative" because Delta smelt migrate through the area where Pyke proposes diverting the water.

Pyke says he can fix that. Instead of a pipe, he proposes building a long levee of coarse sand and rock through which water would slowly flow and fill up the island. He believes fish would float past unharmed. He acknowledges uncertainty, but says there's uncertainty associated with the governor's plan, too.

Pyke has been involved in projects all over the world — from strengthening dikes in the Netherlands, to designing earthquake-resistant dams in the Philippines. He began learning about the Delta issue in 2008 when he was hired by ARCADIS, a worldwide consulting firm that later landed a contract analysing the twin tunnels plan.

In 2010, Pyke was fired. He has filed a $1 million lawsuit alleging wrongful termination; his former employer claims in court papers that Pyke was insubordinate. He previously worked as a consultant on a team hired by the Delta Protection Commission to study strengthening the Delta's levees — another alternative to the twin tunnels.

Wintery Tunnelling under Moscow

Mixed ground, freezing temperatures, and compact urban jobsites are just a few of the challenges for Moscow's epic metro development scheme. The program calls for 150 kilometres of new metro lines within the next eight years—a rate of construction second only to China. Three High Performance Robbins EPBs and one refurbished machine are up to the challenge, excavating at multiple jobsites around the city.

Russian contractor Engeocom is using three EPBs, including two new Robbins machines between Business Center and Park Pobedy Stations.

Contractor Engeocom purchased two 6.6 metre Robbins EPBs to excavate two 1.8 kilometre) long tunnels. In addition, the contractor refurbished their pre-owned Lovat machine with a Robbins cutterhead and spare parts for a 2 kilometrem interstation tunnel. The refurbished machine launched in August 2012, and had progressed more than 265 metres by November 2012. A fourth 6.2 metre Robbins EPB was purchased by contractor USK MOST for a 1.9 kilometre section.

Due to the urban constraints of Russia's bustling capitol, jobsite modifications were required. The Robbins EPBs will be launched from small shafts of 30 metres deep and 15 metres deep, respectively. The USK MOST EPB will also require a shortened launch setup from its shaft, with back-up gantries at the surface. Vadim Bocharov, Managing Director of USK MOST said of the machine: "Robbins has very nice people helping us with this, and good field service. The Robbins machine also has a very nice design; it is a world-class EPB machine. We think this machine has a better steel construction, and is more durable and powerful than we have seen in other TBM brands."

Moscow's geology is characterized by fine sand, gravel, loam, stiff clays and boulders, and all four EPBs are well-prepared to handle the complex geology that lies ahead. Each is outfitted with a mixed ground cutterhead reinforced with abrasion-resistant wear plates, giving the option to interchange carbide knife-edge bits with 17 inch disc cutters when needed.

The four EPBs are the first in the entire city equipped with electric variable frequency drives (VFDs), for faster excavation, minimized disturbance, and limited settlement. For maximum speed and efficiency, Robbins continuous conveyors are carrying muck behind each of the machines.

Challenges include those associated with the fast-approaching Moscow winter, when temperatures average -17 degrees Celsius. USK MOST will be doing extensive monitoring to keep fluids from freezing, but sees a positive side in the low temperatures: "The colder temperatures may help in minimising soil settlement through the winter," said Bocharov. Extensive soil conditioning is also part of the settlement minimisation plan.

Once underway, the machines will join dozens of other EPBs in the largest simultaneous construction by TBMs that has ever taken place in Moscow. Upon completion, the extended metro system is intended to alleviate traffic congestion and lower the average two-hour travel times that currently affect 12 million commuters.

Cutterheads for the Robbins machines have been fitted with interchangeable carbide bits and 17-inch disc cutters.

Three new Robbins EPBs and one refurbished machine were custom designed for Moscow's mixed ground ranging from fine sand to stiff clays and boulders.

New Insights into Tunnel Detection Using Seismic Techniques

Researchers have been deploying instruments for a seismic data acquisition survey parallel to a border fence in California. The acquisition equipment includes an SUV-mounted accelerated weight drop to generate seismic waves.

Sandia's geophysics and atmospheric sciences organisation is nearing the end of a two-year study, "Improving Shallow Tunnel Detection From Surface Seismic Methods," aimed at getting a better look at the ground around tunnels and learning why seismic data finds some tunnels but not others.

The eventual goal is to come up with a seismic detection process for the border and other areas where tunnels pose a security threat. Bonal's project is funded by Sandia's Early Career Laboratory Directed Research and Development program.

Most tunnels are found by tips from people rather than by scientific methods, but if researchers can discover what it takes to pinpoint tunnels, the next step would be to develop streamlined seismic methods that would be more practical for the Border Patrol and military.

The study arose from earlier work at Sandia detecting shallow tunnels but standard refraction and reflection processing techniques Sandia used could not successfully pinpoint some tunnels. Researchers speculate the difficulty might be what's called a halo effect around a tunnel, in which fracturing and other geological anomalies create diffuse boundaries and hide the tunnel. The earlier, broader research produced several successes in tunnel detection, but was not focused specifically on what happens in the area where tunnel and earth meet, which might help explain why tunnels can be detected in some cases but not others.

The current research is looking at whether seismic waves are strongly impacted by fracturing or saturation of pores in rock or soil, as well as varying pressures at different depths. Physical processes change from shallow depths to deeper depths, but it isn't clear just where that change occurs. In addition, the halo effect is both asymmetrical and complex. It's a pretty complex regime just from the hydrology standpoint which depends on the geology or the soil as well as the seasonal variation, rain events and the relation to the water table. More research is needed, but asymmetry may turn out to be an advantage because an asymmetric area might show up better than a symmetrical one. "These anomalous areas are what may be identified as tunnels in the data.

The team ran the hydrology models to get some results, then converted those results into seismic velocities that

could be plugged into Sandia's 3-D elastic seismic wave propagation simulation code, Bonal said. These results will produce synthetic seismograms that will be compared to field data from the real environment and can be used to develop other processing techniques. That will in turn produce data that's expected to look like what's collected in the field. The effects of a tunnel versus no tunnel is then compared and changes in fracturing and saturation of the tunnel halo versus no changes to assess their impact on seismic waves.

The standard used to show the relationship of saturation in pores in rock or earth to seismic velocities is an oil industry standard called the Biot-Gassmann theory. However, few experiments have tested that theory at shallow depths where border tunnels are commonly dug. The few that have been done have shown that the Biot-Gassmann theory tends to overestimate the velocities for those unconsolidated near-surface materials where the pressures perhaps aren't as great as at depths where the oil industry operates.

The very near surface behaves one way, but at some point behaviors change because of greater pressures and other factors, she said. The Biot-Gassmann theory holds well at greater depths where pressure is more intense and the rock is more consolidated, while another theory, Brutsaert, describes what happens very close to the surface.

Experimentally verifying at what depth or in what materials competing theories work best currently lies outside the scope of the project but is hoped to be developed later.

XL TBM for Gdansk

In September 2012, Herrenknecht supplied a tunnel boring machine with a diameter of 12.56 metres for the construction of a road tunnel under the Vistula in Gdansk.

With its freight and ferry terminal and the airport, Gdansk is a major transportation hub in Poland as well as for connections from Scandinavia to Central and Eastern Europe. Now the new ten kilometer long "Słowacki route" is to improve the transport infrastructure in the greater Gdansk area — for more than one million people living in the metropolitan area as well. It links the "Lech Wał sa Airport" with the highway to Warsaw and with the Gdansk deepwater seaport, one of the most important transhipment centres in Eastern Europe.

The "Słowacki Route" will pass under the Vistula with a twin tube tunnel with a total length of 1.4 kilometres. The tunnel tubes will each accommodate two road lanes and will be connected by seven cross passages for escape routes. For the construction of this major tunnel the building contractor OHL ordered a Mixshield with a diameter of 12.56 metres from Herrenknecht. In the middle of September 2012, in the presence of Gdansk City President Paweł Adamowicz, the Chairman of the municipal investment company GIK (project owner), Ryszard Trykosko, Poland country manager Jose Manuel Rubio Roeder from OHL and representatives of the Polish press, the XL machine was accepted at the Schwanau plant.

According to Herrenknecht project manager Peter Griesbach, a challenging advance under the Vistula awaits the machine and the jobsite crews: "At certain points there will only be about 8 metres above the machine to the bottom of the river." The machine will be sealed against penetrating groundwater or subsoil at pressures of up to four bar: between shield skin and lining segment with a triple wire brush seal and a quadruple sealing system on the drive. The equipment was designed in such a way that tunnelling can also be carried out on the steep four percent downward and upward gradients at the beginning and in the second half of the tunnel respectively.

The Group subsidiary Herrenknecht Formwork produced the moulds in which the segments for lining the tunnel tubes are made. As a full-service provider in tunnel construction, at the customer's request Herrenknecht is also supplying additional equipment: the separation plant and the pumps for slurry circulation in the tunnel, the compressor station, the navigation system (VMT), the start-up construction and equipment for the material and personnel transport in the tunnel (MSD). Herrenknecht specialists will support the customer's personnel with service and equipment during on-site assembly of the machine and through to successful completion of the project.

JAPAN SASAGO TUNNEL COLLAPSE

A highway tunnel collapsed in Japan on 3 December 2012 crushing cars, triggering a blaze and sparking fears of another cave-in. Emergency crews who rushed to the nearly five kilometre long Sasago tunnel on the Chuo Expressway, 80 kilometres west of the capital, were hampered by thick smoke billowing from the entrance. Witnesses spoke of terrifying scenes as at least one vehicle burst into flames, sending out clouds of blinding, acrid smoke. Rescuers were forced to suspend their efforts to reach those believed trapped under thick concrete ceiling panels for several hours when engineers warned more debris could fall.

Nine bodies were pulled from vehicles crushed in the tunnel collapse. Five of those were recovered in one charred station wagon, and three others were in another burned vehicle, according to the police spokesperson. The other fatality was in a truck. Officials from the East Yamanashi Fire Department said the section of concrete that fell was about 50 to 60 metres long and about 20 centimetres thick

Emergency crews equipped with breathing apparatus battled around a third of the way into the tunnel, where they found up to 70 metres of concrete panels had come crashing down, crushing at least two vehicles. Footage from security cameras showed large concrete panels in a V shape, apparently having collapsed from the middle, with teams of men in protective gear scrambling over them. It now seems likely that a failure in the suspension system caused the collapse of around 270 concrete panels, each weighing 1.4 tonnes.

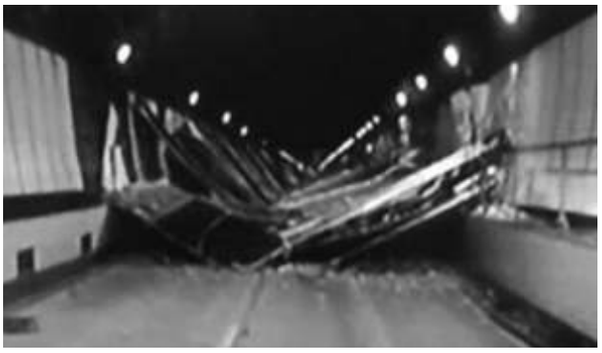
The tunnel, which passes through hills not far from Mount Fuji, is one of the longest in Japan. It sits on a major road connecting Tokyo with the centre and west of the country.

The privately held Central Nippon Expressway Company operates the 4.7 kilometre long Sasago tunnel, among others, as well as expressways and toll roads around Japan. Central Nippon Expressway conducts annual inspections of the tunnel, with one particularly thorough

inspection held every five years, a company spokesperson said. A more intensive inspection of the Sasago tunnel was held sometime in the past two to three months, the spokesperson added.

Japan has an extensive and well-maintained network of highways with thousands of tunnels, usually several hundred metres long. Millions of cars use the network every day. The worrying question revolves around how many other tunnels may now be unsafe. Following the economic boom of the 1960s and 1970s, the country now has more than 1,500 tunnels which allow highways to criss-cross across the land. Though building standards were considered high back then and have been tightened over the past 20 years, experts say the tunnels decay with age, and there are fears that many of the older ones — at least 20 have the same design as Sassago — could be in need of urgent maintenance.

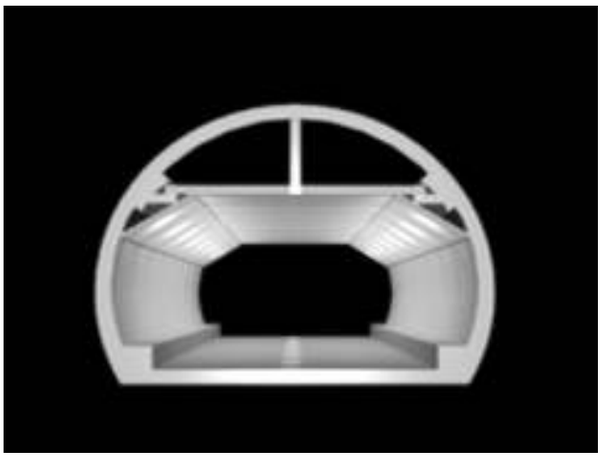
Adding to the concerns, the country is earthquake prone. Experts have warned that older structures built prior to the tightening of standards could be vulnerable to regular movements in the event of seismic activity.



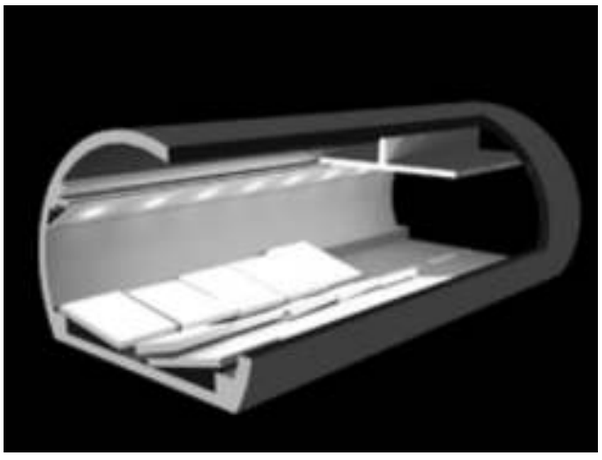
Chikaosa Tanimoto, professor emeritus of tunnel engineering at Osaka University told NHK ceilings are made from concrete panels suspended from pillars. "Speaking only generally, because it is an old tunnel, it is conceivable that the parts connecting the ceiling panels and pillars, or pillars themselves, have deteriorated, affected by vibrations from earthquakes and passing vehicles," he said

Following the disaster loose ceiling bolts were found in the outbound Sasago Tunnel which runs parallel to the one whose ceiling collapsed. Whilst the bolts did not appear to pose an immediate risk of the ceiling's collapse in the wake of the accident, the expressway operator, Central Nippon Expressway Co. then carried out emergency checks on the other tunnel.

The transport ministry has ordered inspections of 49 other highway and road tunnels of similar construction around the mountainous country. Much more of Japan's transportation system may require refurbishing after years of spending cuts that starved projects of funding, including funds needed for basic maintenance. The infrastructure ministry, which is in charge of land and roads, has joined with three government highway operators in forming a panel on how to handle problems of deteriorating expressways and tunnels.



Cross section model of Sasago Tunnel.



Model showing collapsed ceiling panels.

Central Nippon Expressway Co., the tunnel's government-owned operator, said it had no record of any major repairs performed since the Sasago tunnel opened, but company official Satoshi Noguchi said an inspection of the tunnel's roof in September found nothing amiss.

At a press briefing on 3 December, the executive officer of the operator of Japan's Sasago Tunnel said that it appeared some "anchor bolts" used to secure the concrete slabs to the tunnel roof were missing. "There were parts of concrete where bolts had fallen off," Ryoichi Yoshizawa confirmed, according to a spokesman for Central Japan Expressway Company or NEXCO-Central. Yoshizawa added, "The ageing of the bolts or the concrete slabs could be a potential cause." It has also emerged in Japanese Media reports that regular visual checks had been performed on the tunnel, but that there had been no actual physical testing, possibly since the tunnel opened in 1977.

The firm said it didn't conduct hammering tests because the panels were over 5 metres from the ceiling of the tunnel and no bolts or hanger rods for ceiling panels had been replaced since the tunnel opened in 1977.

About a dozen uniformed police entered the company's headquarters in the central city of Nagoya following the collapse looking for evidence of malpractice.

Because the outbound side of the damaged Sasago Tunnel is a two lane artery as well, Central Nippon Expressway Co. converted it for use in both directions as a stopgap measure after removing the ceiling tiles in the outbound tunnel.

The families of five young adults who perished when the Sasago Tunnel partially collapsed have announced the filing of a criminal complaint against the Central Japan Expressway Co. for their mismanagement. The five victims, all in their 20s, were among the nine people who were killed while driving on the Chuo Expressway in Yamanashi Prefecture towards Tokyo.

Calling time on suspended panels

Japanese "experts" have said the accident was caused probably by "faster than anticipated ageing" of the 1976 built tunnel which, along with a host of other Japanese tunnels and roads, was designed originally for lighter traffic loads. The authorities have lost no time in ordering the inspection of no fewer than 49 similarly-constructed tunnels in the country.

Commentators are highly critical of the lack of funding which may have resulted in inadequate and irregular inspections. One headline said the disaster sounded an 'investment warning' for decaying global infrastructure.

In 2006, a similar incident in Boston's Big Dig tunnels resulted in 3 tonne concrete ceiling panels crashing down onto the roadway, killing a car passenger. In both these tragic events, heavy panels were hung from the tunnel roof.

Tunnels in which suspended ceilings are scheduled to be removed across the nation

	Management entity	Route	Name of tunnel
Removal decided	Metropolitan Expressway Co.	Shuto Expressway	Haneda (both directions)
	West Nippon Expressway Co.	Sanyo Expressway	Sekido (Hiroshima-bound)
			Shiwa (Fukuyama-bound)
			Kasaiyama (Kobe-bound)
Removal schedule undecided	East Nippon Expressway Co.	Hokuriku Expressway	Nou (Niigata-bound)
			Takanomine (Niigata-bound)
			Koshirazu (Maibara-bound)
			Ichiburi (Niigata-bound)
		Nagano Expressway	Tachitoge (Chikuma-bound)
		Joshinetsu Expressway	Gorigamine (Fujioka-bound)
			Happusan (Joetsu-bound)
			Taroyama (Fujioka-bound)
	West Nippon Expressway Co.	Kyushu Expressway	Higo (both directions)
			Kakuto (both directions)
	Tochigi Pref.	National Highway Route 122	Nissoku
	Shizuoka Pref.	National Highway Route 150	Shin-Nihonzaka (Hamamatsu-bound)

Haneda tunnel panels removed

After discovering defective fasteners during emergency checks, the operator of the Tokyo Metropolitan Expressway removed concrete ceiling panels from a tunnel near Haneda airport over Christmas. These are the first ceiling panels to be removed from an operational expressway tunnel. The tunnel near Haneda has the same suspended ceiling structure as the Sasago Tunnel.

West Nippon Expressway Co. plans to remove concrete ceiling panels from three tunnels in Okayama, Hiroshima and Yamaguchi prefectures, while East Nippon Expressway Co. is still carrying out inspections to determine whether removal is necessary.

The tunnel near Haneda airport opened to traffic in 1964 and is 300 metres long. The area in doubt is just 20 metres long but has ceiling panels suspended over opposing lanes of traffic.

Each of the narrow ceiling panels is 2.6 metres long, 40 centimetres wide and 5 centimetres thick and weighs 130 kilograms.

The Land, Infrastructure, Transport and Tourism Ministry ordered that expressway tunnels be inspected immediately and ahead of the yearend and New Year holidays, when traffic increases substantially.

Other tunnels

Other tunnels around the world are also being inspected.

In 2006 3 tonne concrete ceiling panels crashing down onto the roadway in Boston's Big Dig tunnels killing a car passenger.

A 3 x 1.2 metre panel fell in the Callahan tunnel in Massachusetts just before Christmas, on 21 December 2012. An emergency closure and inspection resulted in the removal of 117 loose panels from the walls after inspecting every one of the 2,400 enamel coated metal panels that line the roughly mile long tunnel beneath Boston Harbor.

The panels were held in place by a matrix of galvanized metal frames and stainless steel bolts, with the frames bolted to the concrete and the panels hooked onto the frames, but the corroded framework (believed to be only 20 years old) was heavily corroded

Because of annual inspections of all tunnels prompted by the ceiling-tile collapse in a Big Dig section in 2006 highway officials knew that some Callahan panels occasionally came loose because of corroded frames and fasteners. None had ever fallen, and highway workers had either removed or reinforced those panels, believing the problems to be isolated. However with all of the Callahan panels scheduled for replacement in a little over a year, officials had not considered the potential problem severe enough to pull on all the panels to test their integrity.

The Callahan was opened in 1961, and carries roughly 24,000 vehicles a day of eastbound traffic from downtown Boston and Interstate 93 toward East Boston and Logan International Airport. It runs parallel to the older, westbound Sumner Tunnel.

The department is in the midst of building a database to monitor the condition of all highway, bridge, and tunnel infrastructure, to track needs and repair work, using a management tool known as Maximo.

The nearby Sumner Tunnel was then closed for crews to test the stability of 2,400 panels in that tunnel. The Sumner Tunnel was built in the 1930s. 26 panels were removed from the Sumner Tunnel after they were found to be loose after a series of "pull tests".

Officials said the panels will be replaced and that they are looking into a lining system that could possibly better stand the test of time, such as fibreglass.

In 2006 3 tonne concrete ceiling panels crashing down onto the roadway in Boston's Big Dig tunnels killing a car passenger.

New York's flooded tunnels

Floodwaters inundated three of the city's four automobile tunnels, with only the Lincoln Tunnel remaining undisturbed by the storm. The eight subway tunnels flooded in the storm have been pumped clear and returned to service.

The Carey Tunnel is the longest continuous underwater tunnel in the U.S., making it particularly difficult to clear. As Sandy made landfall on 29 October 2012, storm surges rushed from the Hudson River into the mouth of the tunnel and filled its two tubes with what officials estimated was 325,000 cubic metres of water.

More than two weeks after it was flooded by superstorm Sandy the Hugh L Carey Tunnel between Brooklyn and Lower Manhattan partially reopened to car traffic. The tunnel, formerly known as the Brooklyn-Battery Tunnel, carries 49,500 passenger vehicles in its two tubes on an average weekday. The restoration was originally limited to a single direction at rush hour with cars permitted to use one lane of the tunnel's eastern tube and the other reserved for express buses. This restoration marked the first time that all major river crossings into Manhattan were reopened since Sandy bore down on New York City.

The Metropolitan Transportation Authority called it a major accomplishment after nearly 325,000 cubic metres of Sandy's flood waters rushed down the streets of Manhattan and filled all four lanes of the twin tubes, something that shocked even the tunnel's general manager. Half of the tunnel was open for business on 14th November more than two weeks have passed since water cascaded into the tunnel.

"We never had water in this tunnel, ever. The only water we had was from cars, snow. We never had a leak, we don't have leaks. This tunnel is built under bedrock," Marc Mende said.

The ventilation system had to be fixed first. "Fresh air is provided from the bottom portion of the tunnel through the fresh air flews which is then exhausted through the ceiling. In the mid-river portion, 6,000 feet of ventilation was affected by the water," MTA Bridges and Tunnels facility engineer Romolo DeSantis said.

Then the cameras were fixed. "We have approximately 30 cameras in each tube. Their purpose is for disabled vehicles and just life safety systems. They were totally submerged in water, so not only do we have to replace the cameras, but also the power to those as well," Director of Maintenance Charles Passarella said. Nearly 900 lights were still being removed, cleaned, rewired, tested and replaced.

Some of the employees lost homes to Hurricane Sandy, but they continued to work non-stop until the tunnel was fully repaired.

The devastation has underscored how major tunnels across the region are poorly protected from extreme weather and how they will need significant modifications to prevent such catastrophic failures in the future. The tunnel's general manager, Marc Mende, recounting what happened on the night of the storm, made it clear that he had no ability to block the angry rapids he saw heading for the Manhattan entrance. He described the scene as "surreal," saying that he had quickly helped power down a generator and then made a harrowing drive through the nearly two-mile-long tunnel as it started filling with water to make sure his workers had evacuated.

Unlike a number of other tunnels around the world, the Brooklyn-Battery does not have even a basic system to block water at its entrances. No gates or plugs or other barriers. Nor do Manhattan's other tunnels. Defenseless under the storm's ravages, the Brooklyn-Battery instead served as a drain for Lower Manhattan, filling with nearly 100 million gallons of water.

The Brooklyn-Battery Tunnel had never closed for weather, even as a precaution, until Tropical Storm Irene last year. But water levels on the southern end of Manhattan have risen about nine inches since the Brooklyn-Battery Tunnel was opened in 1950. It is a significant increase, since its entrance is just a few feet above sea level.

The Queen-Midtown and Holland Tunnels also flooded, though less severely, during Hurricane Sandy.

Building codes and engineering practices meant to protect urban infrastructure from weather-related disasters have generally not kept pace with evolving scientific knowledge, computer-assisted engineering capabilities and a shifting climate, experts said. The problem is amplified for older structures like the Brooklyn-Battery Tunnel.

"They were using slide rules to crunch numbers," said Mr Klotz, and relying on limited historical weather data to define a worst-case flood. New computer modeling provides guidance and solutions. After one of its coastal plants narrowly escaped flooding during Hurricane Ivan in 2004, Chevron asked Dr Douglass to model its vulnerability. The result was -5.5 metre high sea wall that prevented damage during Hurricane Katrina.

Subway tunnels

The floodwaters that poured into New York's deepest subway tunnels posed the biggest obstacle to the city's recovery from the worst natural disaster in the transit system's 108 year history.

Track beds were covered with debris, critical electrical equipment was damaged, corrosive salt water destroyed essential switches, lights, turnstiles and the power-conducting third rail.

There has always been flooding in the tunnels, which collect storm water constantly, even in the lightest of rains. But authorities said there has never been anything like the damage inflicted by Hurricane Sandy.

New York City MTA chairman Joseph J Lhota declared Hurricane Sandy the most "devastating" disaster in the subway's 108-year history. "The hurricane has flooded seven subway tunnels under the East River and affected "every borough and county of the region," he said.

Seven subway tunnels under the East River were flooded. Metro-North Railroad lost power from 59th Street to Croton-Harmon on the Hudson Line and to New Haven on the New Haven Line. The Long Island Rail Road evacuated its West Side Yards and suffered flooding in one East River tunnel. The South Ferry subway station, at Manhattan's southern tip, had water up to its ceiling.

The high water meant inspectors weren't immediately able to assess how badly the water had damaged key equipment, of the system that shuttles more than 5 million riders to work and home every day.

Mayor Michael Bloomberg guessed it could take four days for train services to resume, and even then it was unclear how much of the nation's largest public transit system would be operational.

Seven subway tunnels took on massive amounts of water during the night as the rivers that surround Manhattan rose to record levels. Floodwaters inundated parts of the PATH system that brings commuters from New Jersey to the World Trade Center site and midtown Manhattan, and the river tunnels that allow Amtrak trains to connect with New York City also filled with an "unprecedented" amount of water.

The subway system has built-in pumps that typically remove 13 million gallons of water from the tubes across the city. Special pump trains had to be deployed to handle the extra load. The MTA cut power to tracks before the flood, hoping to minimise damage.

There were other problems in the transportation system. Some rail yards and bus garages took on water. Sludge and debris covered some tracks. Trees blocked bus routes.

Workers needed to walk hundreds of kilometres of track on foot to search for damage. At least 40 Long Island Rail Road power stations lost electricity, and the overhead power lines that allow Metro-North trains to operate were damaged in several areas.

One diesel-powered patrol train inspecting the Metro-North's Hudson line, which runs north along the Hudson River, found a 12 metre long boat blocking the tracks in Ossining, N.Y.

The subway system had only three mobile pumps mounted to trains for the entire system, additional pumps were provided by Xylem, a water technology company spun off from ITT Corp. Xylem used 12 inch submersible and ground-mounted pumps, both with cast-iron frames, to clear out the water. A 12 inch pump is about 2.5 metres wide and 4.2 metres long and is powered by either Deere or Caterpillar diesel engines, and need refuelling about once a day. Each subway tunnel required four pumps that could remove 13,800 to 5,500 litres per minute, allowing 27 million litres per day, per tunnel to be drained.

Amtrak, experienced flooding in four of the six tunnels it uses to pass through New York City, sought $336 million from Congress to pay for the damage, to improve infrastructure and cover operating losses. Surging waters damaged 62 of the authority's 203 locomotives, including one-third of the engines that can run on either diesel or electric power. It also left 261 of 1,162 rail cars in need of repair. Many of the cars and locomotives were left at low-lying rail facilities in Kearny and Hoboken, New Jersey.

NJ Transit officials are looking at ways to work with Amtrak to protect electrical substations, such as the one in Kearny on the Northeast Corridor line, from being flooded. Officials are looking at locating electrical equipment as high as possible in facilities. Port Authority officials also are looking at partially installed security gates at vehicular tunnels and whether they can be modified for use as flood gates. It also means rethinking where rail equipment is stored.

Huge plugs could have spared subways from flooding

Huge inflatable plugs -- now being developed by the federal government to protect subway tunnels from terrorist attacks -- likely could have saved some of New York's subway tunnels from storm-related flooding, according to plug developers, some of whom are wistful that development wasn't completed in time for Hurricane Sandy.

The Department of Homeland Security successfully tested a plug in January 2012, using the –5 metre diameter prototype to hold back pressurised water at a test tunnel in Morgantown, West Virginia. Further tests are being scheduled.

Project managers have said only one current generation plug has been manufactured, and that they are two years away from marketing them to the nation's transit and highway authorities.

"If we would have had these things installed in the right places (in New York), they could have made a terrific difference," said Greg Holter of the Pacific Northwest National Laboratory. "The problem is we don't have a

One diesel-powered patrol train inspecting the Metro-North's Hudson line, which runs north along the Hudson River, found a 12 metre long boat blocking the tracks in Ossining, N.Y.

stock of things that we could put in place. It's not like we have a bunch of these sitting in a warehouse," Holter said. "It's a little frustrating really that we weren't at a better stage at this thing."

However a letter to World Tunnelling in December 2012 from David Caiden of Arup in New York stated that these plugs would not have been successful as "there are other direct water paths into the tunnel". He goes on to explain that the overflowing Hudson River poured in through vent shaft access routes, and not the portals of the Holland Tunnel, and that "so far as the MTA subway system is concerned, damming of portals would be completely ineffective. Why? Because the whole system is open to the streets through the ventilation grates. Every time there is heavy rainfall in NYC, the surface storm water flows through these gratings into the subway. In a way, it acts as storm water sewer flood relief. The MTA has special pump-cars and hydrant mains along the tunnels to allow tunnel flood water to be sucked up. Unless the street gratings can be completely closed off (an almost impossible task to retrofit a modern air-conditioning and ventilation system with raised vent shafts) and existing entrances raised, there is no practical way to stop the present subway system flooding."

How giant tunnels protect Tokyo from flood threat

On the outskirts of Tokyo, behind a small government building, underneath a soccer field and skateboard park, sits a remarkable feat of engineering.

It's an example of how Japan's capital, which lies in a region at high risk from flooding and tropical cyclones, is trying to figure out how to contain the elements to protect its 13 million inhabitants.

The entrance, which is locked at all times, is so nondescript a visitor may walk past dozens of times without ever noticing it. But today, we are given a tour down below the so-called "Water Discharge Tunnel."

Built between 1993 and 2006 at a cost of nearly $3 billion, the stunning complex is far more impressive than its name suggests.

Winding down a series of stairs, you soon come upon a massive hall, resembling an underground Parthenon, or a scene out of a science fiction film.

The initial water tank stretches more than 320 feet 98 metres in length and towers higher than a 5 story building.

When you add it all up, the complex features 5 massive shafts, or tanks, that are able to move water along a tunnel that stretches nearly four miles.

In this area of Saitama prefecture, heavy rains would often flood the Naka River Basin. But now, that valuable farmland has an incredible drain system sitting below.

When the tanks and tunnel fill, engineers are able to turn on the heart of the system, which is a series of 4 turbines powered by jet engines similar to those used in a Boeing 737 airplane. The turbines are then able to rapidly funnel floodwaters to the nearby Edo River.

It's worth noting that this part of suburban Tokyo can hardly be compared to the dense underground of New York City, which is a maze of subway tunnels, sewage systems and power lines.

The engineers here are the first to point out that their system, while remarkable, is meant to deal with heavy rains -- and that it would struggle to cope with a Sandy-type storm surge coming from the Atlantic Ocean into New York's Upper Bay.

Still, the underground marvel could inspire engineers to look for new ways to try to contain Mother Nature in the future.

DC plans tunnels to ease flooding

Storage tanks and a tunnel that could hold millions of gallons of stormwater are being proposed to provide flood relief to two Washington neighborhoods.

District officials unveiled the plan for the Bloomingdale and LeDroit Park neighborhoods of Northwest Washington. The two communities were hard hit by flash flooding last summer.

The plan calls for converting the former McMillan sand filtration site into 2 storage tanks holding 3 million gallons each, and a 6 block tunnel under First Street would hold 6 million gallons. The McMillian phase is expected to be completed by 2014 and the tunnel by 2016.

Sewer authority officials say the plan will cost $40 million more than previous flood relief plans, and it would be finished by 2022 — three years earlier than the previous plan.

DAVID SUGDEN AWARD 2012

Voids and cavities in tunnelling: why do they occur and how to detect them using non-destructive methods?

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Abstract — ***Tunnelling by a Tunnel Boring Machine (TBM) encounters a range of ground conditions ranging from hard rock to soft ground. To maintain the stability of routed ground, treatment is required both before and during the advance of the machine. Due to difficult geological conditions and incomplete grouting, cavities and voids can be created around the tunnel excavation. These can cause unpredictable settlements of the ground and peak stresses in the tunnel lining. So far, these hollow or water-filled spaces have only been detected manually by boreholes driven through the crown of the tunnel lining. Non-destructive methods can be used as an alternative method to detect these spaces.***

Keywords; TBM, ground stresses, voids, non-destructive methods, FDTD.

Introduction

Tunnelling technology has significantly advanced in the past few decades. Meguid and Saada recently wrote [1] that due to the increase in urbanization found all over the world, tunnelling has become a preferred construction method for transportation and underground utility systems.

When tunnelling with a boring machine (TBM) in soft ground, the face must be reliably supported during excavation and the surrounding ground behind the shield tail must be held in balance by grouting during the erection of the lining [2]. To control changes in stresses and resulting settlements, simultaneous backfill grouting was carried out in shield tunnelling for the first time in 1982 in the construction of the Osaka Subway, Japan. Since then, this method has been introduced and continuously applied in many regions of the world, therefore reducing settlements or predicting the range of it associated with shield tunnelling [3].

As is generally the case in soft ground, the main objective is to preserve the initial stresses and in particular to avoid unintentional over-excavation. Therefore, the body of ground surrounding the tunnel drive should not be too damaged by overbreak or loosening/relaxation. Settlements that appear at the surface are one of the indications of inadequate tunnelling. They show the extent to which the lining is embedded in the ground [2]. Based on ITA/AITES [4] there are four types of settlements which occur during the TBM tunnelling: (a) over-excavation, (b) ploughing/heading effect and steering, (c) lining deformation & inadequate grouting and (d) swelling/consolidation of surrounding ground.

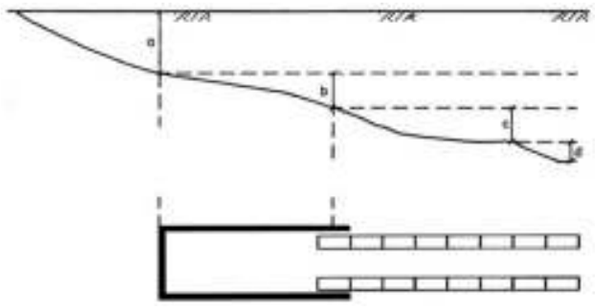

Figure 1: Evaluation of settlement along the shield (adopted from [4]).

Significant work [5] has been done on tunnels that are excavated through pre-stressed soils. Tunnels are acted upon by in-situ vertical and horizontal stresses. Babendererde [2] analysed boring machines specified for soft ground and he stated that if a tunnel is driven with a Slurry or an EPB shielded machine, additional action to improve or change the property of ground is not necessary. Babendererde [2] was almost correct, but there are many hidden or unforeseen factors which can occur during the construction, and or, excavation with a TBM. Therefore TBM manufacturers continually aim to improve their technology, so that they can reduce the factors of possible faults which may occur. Even if the machine is of a "perfect" build, it is always necessary to define precisely the geological conditions that the machine may encounter. In addition, tunnelling methods and the machine's systems, designed to meet the challenge of geological difficulties, must be tuned at the site and their effectiveness monitored during the whole construction.

Excavation and Tunnel Integrity

Introduction

"Tunnels are built for rails, roads, passages, sewage, water, utilities, etc. For the majority of people the tunnel function is the most important aspect, but for a tunnel engineer the type of tunnel construction and geological picture are the most important criteria". So began Mr. Garry Humphrey [6] in his opening speech at an ATS Tunnel Design & Construction short course in Sydney, Australia. The main purpose of tunnels is its function and therefore the final outlook of the tunnel reflects just that. Technical machine developments are now available which virtually allow us to drive tunnels in even very "difficult ground" [2]. By "difficult ground" Babendererde [2] was referring to difficult geological conditions in which, during the tunnel

drive, the face is only partly or not at all stable, the tunnel lies in the underground water, the ground conditions often change, or the strength of the excavated material is extremely variable. Professor Barla [7] presented a problem of "difficult ground" conditions when TBM machines are used in tunnelling where an overburden can reach up to 2000 m. There are often geological layers with faults or natural effects such as high strength rock boulders, squeezing rock conditions, underground cavities, high-pressure water entrapments, Karst underground cavities and so on (see Figure 2). When excavating in soft ground, the surrounding material must be supported at all times and the cross-section of the tunnel secured [8]. The support medium of the face on Slurry Shield is virtually a frictionless fluid. It consists of water and additives that can filter out and settle on the surface of the face to form an impervious layer. While using the EPB, the cohesive soil loosened by the cutting wheel serves to support the tunnel face, unlike other shields which are dependent on a secondary support medium [9]. Even when the groundwater is included, the properties of the support medium are at best those of a non-frictionless, high-viscosity fluid. The more homogenous and consistent the soil is, the more successful tunnelling with EPB will be [2].

Segment lining

Due to overburden pressures, underground water and consequently high hydrostatic pressures, tunnel lining requires prefabricated watertight reinforced concrete components with the highest degree of dimensional accuracy. When excavating, the fitness for use and durability of tunnels depends critically on the quality of lining segments [9]. In this matter high precision prefabricated curved concrete lining segments are assembled to form a lining ring. The TBM's vacuum lifting equipment lifts and positions the segments into the allocated place and locks it in with a smaller diameter "key" ring.

The faces of all segment joints need to be cleaned before bolting segments together. All bolts are tightened at the time of erecting each ring and then retightened prior to forward advance after erection. After the lateral loading on lining rings, due to the erection of the machine and the back support against the ring, the bolts can be removed as the lining only withstands hydrostatic compression loads. The procedure of tightening leaves a precise result in lining placement accuracy within a +- 0.5 cm range. A lining that is unsatisfactorily bedded may result in bending or deformation, which can lead to local overstressing and possible cracking, damage or collapsing of the segment [2]. Stresses within the tunnel lining at critical locations are measured with strain gauges.

Primary grouting

It is important that the lining is fully assembled and no voids exist between the surrounding ground and the concrete segment. In the shield tunnelling construction process, after the lining placement, primary backfill grout mortar is injected through the tail skin of the shield into the gap between the lining and the ground. The pressure due to simultaneous backfill grouting starts acting on the circumference of the lining immediately after the passage of the shield tail. The grouting pressure distribution becomes uniform shortly after the grouting because the grout is in the plastic state. With the hardening of the grout, the earth and water pressure are conveyed onto the tunnel lining. Before soil to lining interaction begins, these stresses undergo some changes resulting in displacements in the soil mass. The magnitude of the

Even when the groundwater is included, the properties of the support medium are at best those of a non-frictionless,high-viscosity fluid.

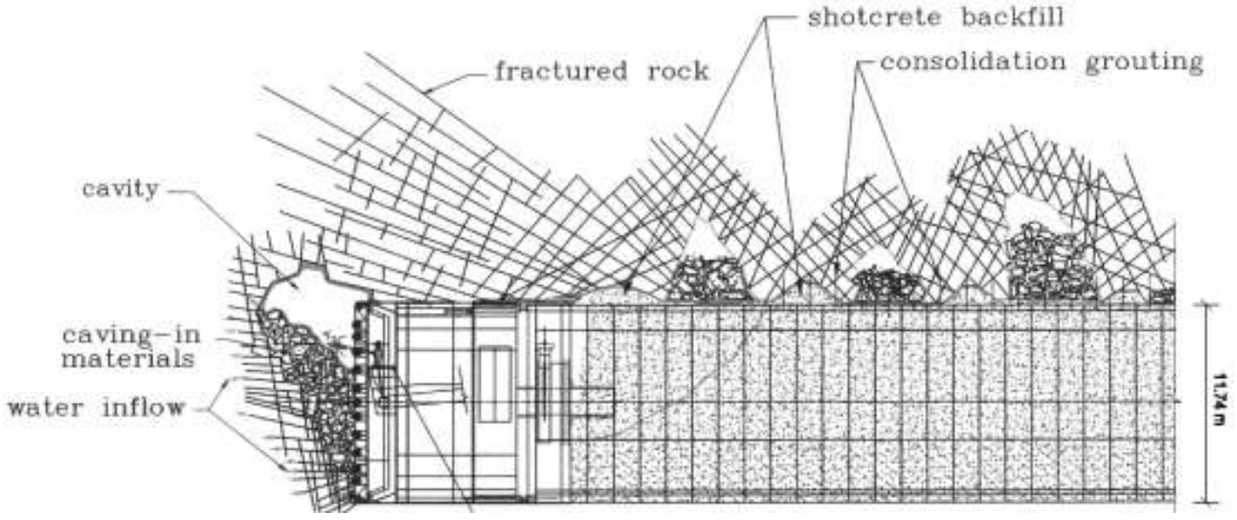

Figure 2: Examples of instability problems at the tunnel excavation (adopted from [7]).

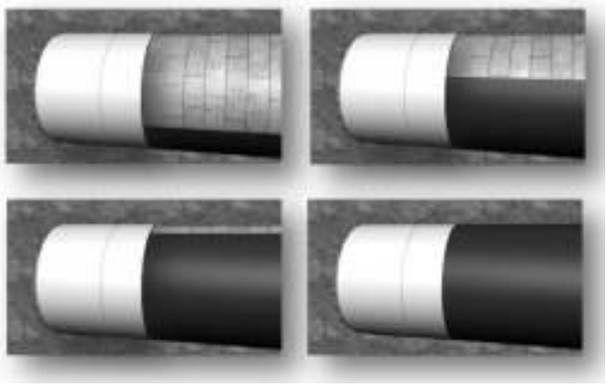

Figure 3: Simplified interpretation of TBM shield tail backfill grout mortar injection (modified from [11]).

pressure change depends on the ground condition, e.g,. hard or soft soil, and also on the magnitude of the injection pressure. In the case of soft soil, the lining pressure approaches the initial stress through time regardless of the magnitude of the injecting pressure. In the case of hard soil, the lining pressure approaches the active earth's pressure [3]. This means, the stresses acting on the tunnel lining will be lower than the original stresses, particularly for the tunnels constructed at some distance from the ground surface [10]. On the other hand, when a twin tube tunnel is constructed, these pressures need to be taken into account, due to the influence on the neighbouring tunnel lining.

Secondary grouting

Although the conditions of grout injection are adequately controlled, there is no confirmation that primary grouting has filled all the available empty volume between the concrete lining and the surrounding ground. Efforts to estimate the grouted volumes are based on: (a) geometry, (b) permeability of the surrounding ground and (c) applied pressures. Regardless of the above factors and information, these parameters are still unable to supply reliable information [12]. Where there is an indication that primary grouting has not fully filled the annulus, then proof or secondary grouting is specified by the designer and carried out with the approval of the construction certifier. These indications can be shown as water ingress,

In the case of soft soil, the lining pressure approaches the initial stress through time regardless of the magnitude of the injecting pressure.

wet patches on concrete segments, unexpected local concrete cracking or even ring sagging (over-stressed concrete, due to possible ground collapse). Because of the mentioned issues, every segment is equipped with one or two threaded cap grouting sockets. If additional grouting is required, tunnel ring is subjected to secondary grouting. The grout hole is extended through to the exterior surface of the segment by drilling in a manner that does not cause damage to the concrete beyond the intended diameter. If this is carried out, the maximum secondary grouting pressure should not exceed pressure specified by the tunnel design/geology, due to the possibility of over-stressing the surrounding ground. These pressures have the potential to cause surface heave (at shallow excavations) or induce displacements by impacting on nearby structures such as the lining of a twin tunnel or the foundation of a high-rise building. Upon the completion of secondary grouting, each grouted hole is left in such a way so that the grout plug can be reused during the period of tunnel excavation.

Conventionally, the presence of voids within the grout are detected by drilling holes along the crown of the completed TBM tunnel ("blind grout injection holes") in the location where any lack of grout is most likely to occur. The probe holes readily locate voids that the grout has not filled, although they do not reveal the extent of the void along or around the crown. The assessment of the efficacy of grouting is not trivial [13]. One way is core sampling, which of course is destructive and not representative of a large area.

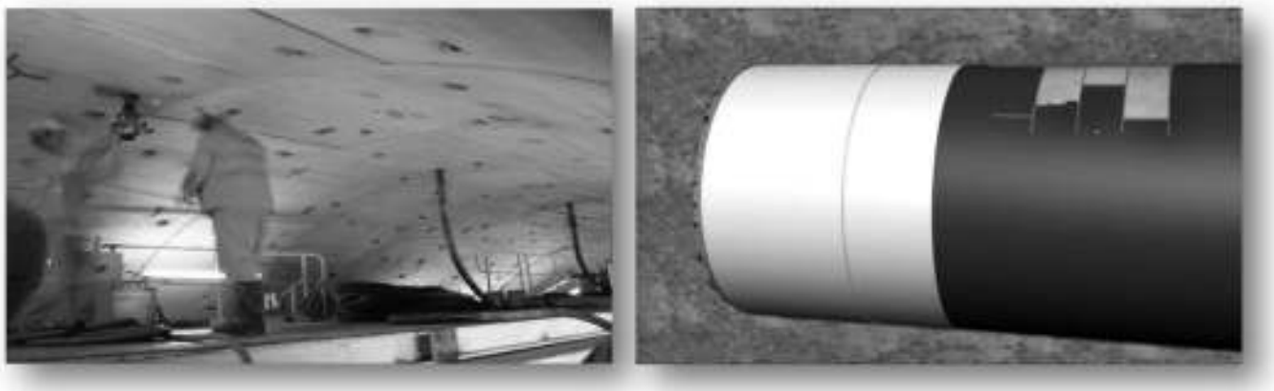

Figure 4: Secondary grouting of every second segment (courtesy Mr. Michael Huber) and potential insignificant primary grouting (modified from [11]).

Non-Destructive methods

Introduction

A variety of manual and mechanical augers/probes have been investigated by Johnson et al. [14] as basic tools used in examining soils, marking a soil survey and for investigating hydrologic and geological characteristics close to the ground surface. The number of observations is limited by time and money; however, they are spaced to best define the area being surveyed, which helps geologists in their understanding of soil formation, vegetation, natural drainage topography, and other features in the landscape.

Additionally, this work is highly labour-intensive and relatively slow [14]; the quality of the results is a function of the variability of the area being mapped. To improve the definition of a complex area, a greater number of observations are required per unit area. In these circumstances time limitations and costs may become unreasonable or prohibitive. Due to these reasons there should be a higher tendency in using geophysical methods that allow gathering subsurface information rapidly and economically, as well as providing continuous line coverage of an area.

Non-destructive geophysical measurement method can be used to detect and determine the possible anomalies or material changes. Anomalies may include the presence of foreign targets (e.g. rock, buried utilities, cavities), deteriorated materials, water infiltration within the structure or other undesirable elements (e.g. conductive ions) within the structure. The ability to detect a target depends on the contrast between the dielectric parameters of the target's material and the material that the radar energy had been travelling through before encountering it [15]. The magnitude and phase of the reflected wave can indicate the relative change in parameters of the anomaly relative to its surroundings. Changes in the travel time and attenuation of the propagating signals can also be used to detect and determine the properties of anomalies or material changes. The greater the contrast between the parameters, the more visible the target is. In applications where the target is made from metal (e.g. rebar, pipes) the contrast in comparison with soil is much greater and therefore the target's resolution is better.

Overview of Non-Destructive methods

Further on this topic, the Texas Transport Institute [16] combined and reviewed all high-frequency, as well some high-speed non-destructive, methods in order to interpret the mapping of: (a) tunnel leaks, (b) concrete creaking, (c) concrete spalling, (d) concrete delamination, (e) debonding, (f) steel corrosion and (g) improper drainage of existing tunnel structures. The main focus [16] was to propose a high-speed solution for tunnel monitoring and its structural properties. Based on the method, tunnel closure would not be necessary while under the monitoring / scanning stage.

Using the above reference, an overview of the non-destructive methods has been summarised in Table 1. The summary below discusses and focuses on non-destructive methods which could be of most effective use if or when implemented in a TBM, while still in the excavation phase of tunnel construction.

Methods most relavant for TBM tunnelling

- ***Impulse Response (IR) and Impact-Echo (IE) — "Time-Trigger"***

At the Hallandsas Project in Sweden a non-destructive method has been applied, tested and implemented in the tunnel and approved by the Swedish Transport Administration, to check the backfill material in segment lined tunnels. Due to difficult ground conditions and groundwater pressures, a significant outwash of backfill material was experienced during construction. The outwash resulted in incomplete backfilling and consequently unacceptable movements of the tunnel lining. A Pea-Gravel was used with excellent "running" properties, filling up to 2/3 of the annular gap to allow the water drainage along the lining. Top part of the lining ring was grouted with mortar. At a later stage, Pea-gravel was eventually grouted to create a complete matrix. At the end, sufficient backfill was achieved by creating a large amount of backfill drill holes. Therefore, a strong ambition was created to reduce the number of backfill drills and implement a non-destructive method, which defined a range between "good" and "poor" grouting and sometimes something in-between, a "questionable" status.

With this method a fast and easy detection of voids behind the tunnel was achieved, but a great amount of measuring points is required to calibrate the system, to understand the limitations of the device as well as to indicate the right resonance frequency and associated amplification. The device is point wise / impact by nature, therefore it cannot provide a 100% coverage testing area. In addition, if the layers are not fully bonded, the signal cannot penetrate further into the medium, resulting in a possible misunderstanding of the size and extent of the void or cavity.

The implementation of the Impact-Echo method within the tunnel was given a 2011 Innovative use of Instruments Award in Tunnelling as well as an outstanding review from the judges: *"Like all great ideas this one is very simple. It is an advance in the industry's approach to cooling the tube, reducing the operational cost of the tunnel and making tunnel more sustainable. The concept is fantastic and it presents one of the biggest pot5ential steps forward for the industry for many years"*[17].

Figure 5 Impact Echo Device (adopted from [16]).

Table 1: Overview of Non-Destructive Methods For possible testing of Tunnel's integrity in Bored Tunnels (revised from [16])

METHOD	PROS	CONS
GPR — Ground Coupled System	• Low frequencies/great signal penetration depth • High frequencies/excellent near surface high resolution • Detection of concrete cracks, reinforcement, corrosion, utilities • Evaluation of layer distribution/thicknesses • Detection of voids behind the segment • 3D mapping of areas with high moisture content	• Low signal penetration in cohesive/ wet soils • High frequencies/poor in depth signal penetration • Low frequencies/poor resolution at low depths/hazy zone • Reinforcement disruption with signal penetration • Surface/ground coupling problems • Grid collection of data/hard pin point detection • Large equipment/antennas/stands • Long data acquisition/subjective data processing/large data
GPR — Drill Hole System	• High resolution for mapping of cracks • Evaluation of layer distribution/thicknesses • Detection and evaluation of reinforcement	• Destructive method/a drill hole needed • Point wise by nature • Low frequencies only
GPR — Air Coupled System	• Fast data acquisition • Repeatable and accurate measurements/monitoring • Works well with thermal camera/moist-water detection	• Quality of data/changing nature of signal can be caused by different heights/ distances from the surface • Interference from other signal devices/ large conductive objects • Large equipment/antennas/stands
Impulse Response (IR) and Impact-Echo (IE)	• Detects delamination of linings and their thickness • Detection of voids behind the segment • Fast and easy to use	• Discrete/Point wise by nature • Not feasible for rapid, 100% coverage testing • Cannot provide deeper layers if the layers are not fully bonded
Ultrasound	• Detection of cracks, voids, deterioration of concrete/ grout • Pulse time can determine the thickness of concrete/ grout • 100% coverage testing • Inexpensive in comparison to other methods	• Multiple measurements needed to obtain an image • Long data acquisition • Needs to be in contact with the structure to generate a signal • Poor repeatability and/or consistency
Ultrasonic Surface Waves (USW)	• Quality control of concrete's strength • Evaluation/forensic assessment to detect delamination, debonding and loss of strength due to internal concrete cracking • Fast data acquisition	• Qualitative variation of modulus with depth • Discrete by nature, not feasible for 100% coverage testing • Does not provide deeper layers past de-bonded or delaminated layers
Ultrasonic Linear Array (MIRA)	• Multi-sensor Ultrasonic Echo system • Detection of cavities, flaws, cracks, honeycombs • Ability to see beyond reinforcing or distinguish metal enclosures from voids by phase analysis • Grouting defects around tendons or behind tunnel lining • Extent of vertical cracks/or their repair • Real time 2D image with ability to scan over a rough surface • Fast data acquisition (less than one second for a scan)	• Physical contact with the surface is limiting the collection of data • Objects thickness cannot be less than 50 mm, shallow defects will not be detected

METHOD	PROS	CONS
X-Ray monitoring	• Fully portable and compact, for rapid x-ray based inspections within structures • Detection of cables, voids within concrete	• Device needs to have a lead shield/ perfect conductor on the other side of the investigated object to obtain a clear image • Radiation
Concrete Surface Resistivity Testing	• Estimation of concrete's permeability/steel corrosion	• Slow and point wise by nature • Good knowledge of the device and material to determine the permeability/ corrosion rate
Percometer meter or Dielectric probe technique	• To obtain dielectric parameters of measured materials • Detection of free moisture in concrete • Monitoring changes of material under heavy loading • Fast data acquisition/Small/Easy to use • Possibility to indicate salt content due to conductivity change	• Point measurements/Grid collection of data to determine the contour map of an area • Surface probes need a flat smooth surface for good connection • Not good for shotcrete concrete investigation
Digital Photogrammetry	• Fast data acquisition/Low cost/Easy to transport • Continues monitoring of tunnel lining/deformations • 3D mapping/modelling of a tunnel • Possibility to characterize aggregate	• Camera calibration/Only surface visualization • Strait-line data acquisition • Multiple vantage points to avoid obstacles
Laser Scanning: Space Tunnel Scanner	• Contact free, high speed measuring method • Three different, simultaneous measurements • 3600 full-surface visual recording with a thermo recording • High resolution images to detect the smallest cracks and fissures on the tunnel surface • Conduct regular inspection of damage to plan repairs	• System requires a stand/vehicle to obtain (No-movements) • Compared images need to be taken, from the same location to post process the data
Thermal Camera (IR-Camera) System	• Possible crack/distress detection with high pixel cameras • Monitoring of drainage/leakage of structures • Freeze-thaw weakening • System quickly covers a wide range of surface • Low cost/Fast data acquisition	• Dust in tunnel air may interfere with readings/data acquisition • Only surface/visual interpretation. • Needs to be in a collaboration with a GPR or a different method
Structural health monitoring	• Strain gages within structures to control the deformations • Tilt meters to monitor the changes in angles/ bending moments • Temperatures and humidity meters • Compressive and tensile strength of coating or concrete	• Imbedded within the segment structure prior moulding • Devices need to be wireless and run on battery • Installation of devices needs to approved before the construction

- ***Ground Penetrating radar***

The National Cooperative Highway Research Program, America [18] did an overview research of the GPR implementation in tunnels for the purpose of monitoring and retrofitting evaluations. Both ground coupled and drill-hole GPR antennas have been used to observe bedrock stratification and identification of major fracture zones in bedrock. Other applications have been used for measuring concrete wall thickness, locating rebar or detecting voids between concrete and the bedrock and leakage of drainage water. GPR has also been used to test grouting behind tunnel walls [18].

Parkinson and Ekes [19] had an opportunity to investigate a working 2.3 m diameter water tunnel, which was closed for retrofitting, in order to investigate the tunnel's integrity and water tightness. Half of the tunnel was built using a drill and blast technique and the other half with a TBM. The whole tunnel was fitted with segment lining to create a water pipe. Segments were imbedded within the pre-excavated hole with non-grouted alluvial gravels or filled/wedged with concrete. The total length of the investigation was 8.8 km and the anomalies found were: (a) concrete honeycomb, (b) steel reinforcement and mesh roof support, (c) embedded square set wooden timbers (used to help with the alignment of the segment lining while under construction), (d) Liner-Rock contact, (e) voids empty or filled with water, (f) faults in concrete causing water leakage and (g) faults in surrounding rockmass. The archived depth of the radar signal at the crown of the tunnel was 1 m using a conventional GPR. Interpretation of obtained data was point post-analysed, using a destructive method, which drilled though the segment lining and investigated the routed hole. The average radar velocity in the concrete was approximately 1.06 m/ns and the air velocity within the open tunnel was 3.33 m/ns.

A method based on GPR to detect grout thickness behind the concrete lining and to evaluate the effectiveness of the shield tunnel backfill grouting technique had been proposed at the Shanghai Metro Line, China [20]. Tests were conducted on the lower side of the tunnel ring to enhance the integrity of the grout. Due to the concrete segment and to the grout and soil being within an overall distance of 1 m, GPR non-destructive technique was well chosen.

As laboratory knowledge of the dielectric parameters of each material had already been established and the thickness of the concrete segments was already known, only the boundary between the grout and the soil needed to be found. Three GPR antenna frequencies were initially used (250 MHz, 500 MHz and 1 GHz), with 500 MHz showing the most promising results. To obtain the figure 7, multiple filters and signal gain were used in a post-process phase of the raw data signal obtained by the GPR [20].

Interpretation of raw signal data obtained by a non-destructive method

The extraction of information from non-destructive methods is often not a simple process (see figure 6). This is mainly due to the complexity of the factors involved in the method's detection mechanism. Interpretation of data is strongly dependent on the experience and expertise of the user. Difficulties arise when just going beyond the stage of detecting underground features using non-destructive methods to extract specific information about the nature, type, size, location and other characteristics of targets obtained by the method. This is mainly due to the complexity of the factors involved in the detection mechanism and how the transmitted signal is propagated within the medium [22].

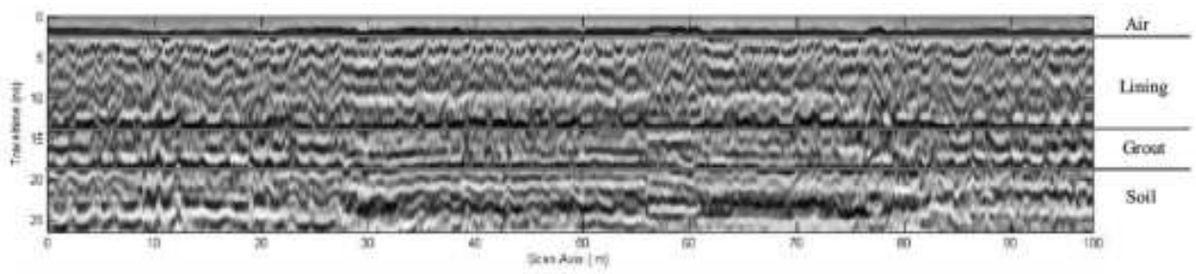

Figure 6: GPR Radargram (Row data) collected from the site (adopted from [21]).

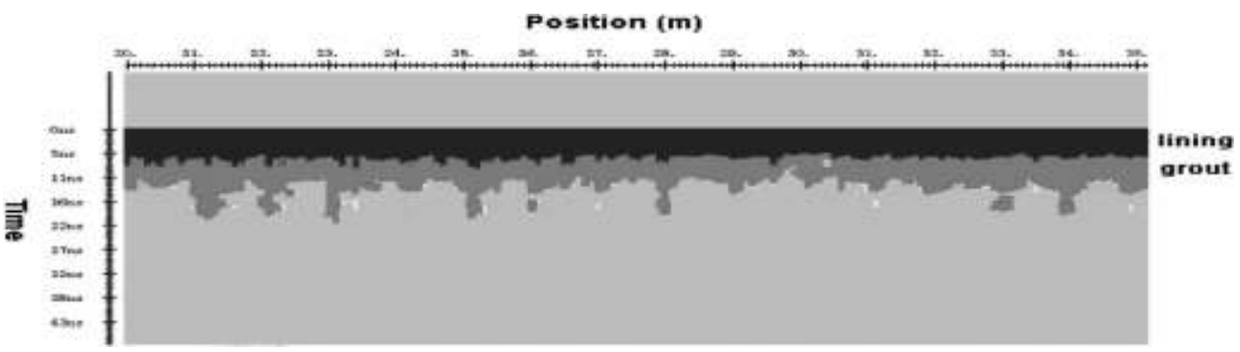

Figure 7: Post-Processing GPR radargram image (adopted from [20]).

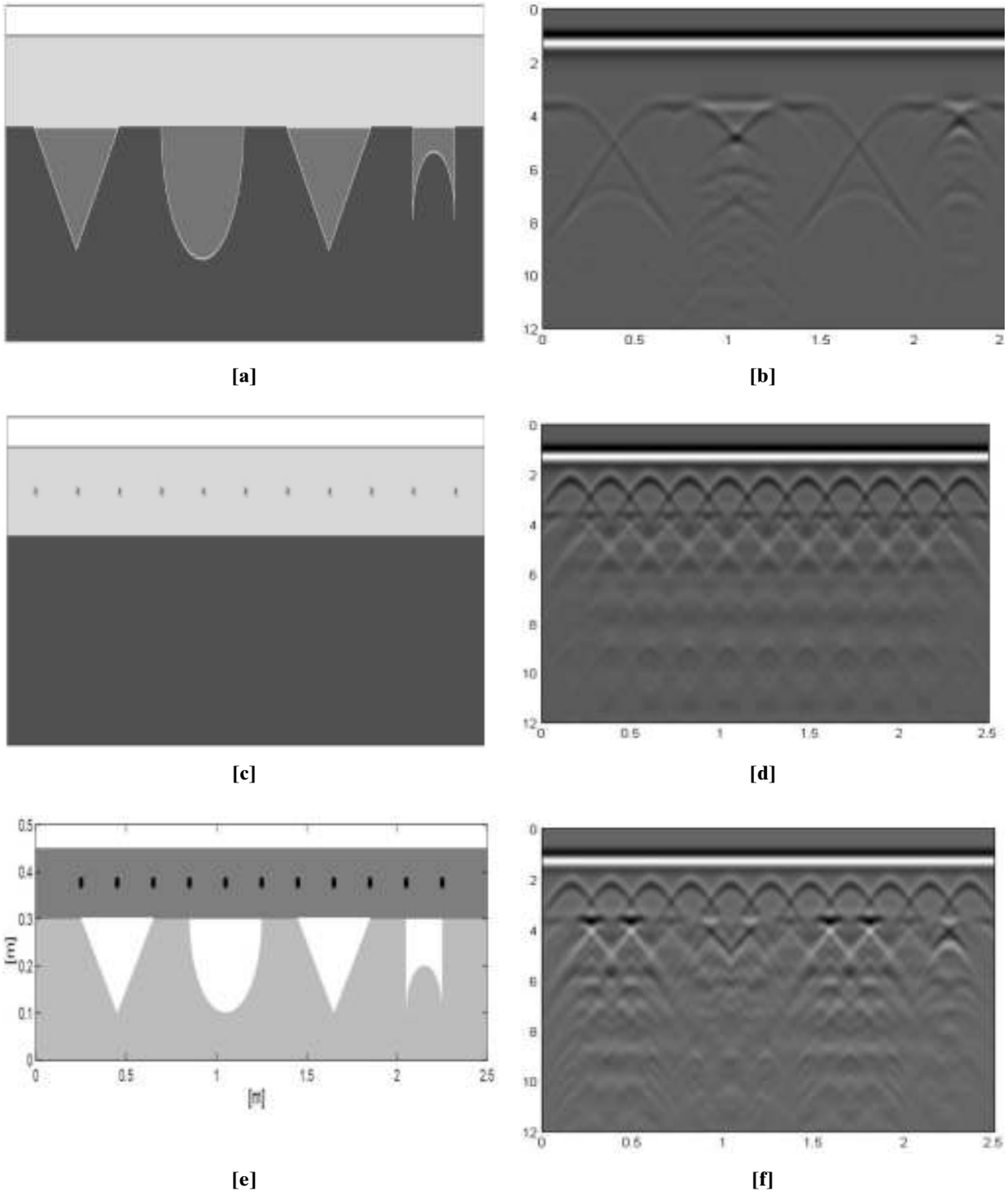

Figure 8: GprMax V2.0 simulation: Concrete block placed on wet sand with different shape voids underneath [a-b]; conventionally reinforced concrete block placed on wet sand [c-d] and conventionally reinforced concrete block placed on wet sand with different shape voids underneath [e-f].

There is a wide range of different modelling methods available with applications falling into two broadly defined research fields: the 'antenna modeller' and the 'propagation modeller' [23]. Antenna modelling is almost exclusively the domain of the electrical engineer and thanks to the technological demands of the mobile telecommunications market, this has provided the GPR antenna designer with a wealth of sophisticated modelling tools. Propagation modellers, on the other hand, are usually more interested in the mode, form and scattering/reflection characteristics of the propagating, electromagnetic GPR wave rather than the specific properties of the antenna. They are driven by the need to interpret GPR survey data and are less likely to be concerned about the absolute accuracy of the modelled results.

Finite-Difference Time-Domain (FDTD) modelling

Extraction of information such as underground features obtained from a radar gram as well as simulated with a Finite-Difference Time-Domain (FDTD) model GprMax V2.0 presents us with a dilemma. When analysing the radargram, detection of material with high permittivity contrast can be clearly seen, but due to strong reflection of transmitted signals from the perfect conductor (steel bars), deeper targets or different layers can be easily neglected or not even recognisable. For this matter and for a better understanding on how the signals propagate though the medium, a FDTD GprMax V2.0 simulation was created by placing a concrete slab on wet sand with voids of different shapes and sizes within the sand [a-b]. The purpose of this model is to present the complexity of the simulated radargrams and their interpretations [e-f]. This complexity occurs when trying to extrapolate data from the radargram [f]. Therefore simulations of radargrams are very important tasks, which help us understand real radargrams obtained from the construction site. By adding just the conventional reinforcement to the concrete slab [c-d], the simulation becomes difficult to understand and objects (targets/voids) are less recognisable to an untrained user.

Due to GPRMax being a perfect model, there is no noise interface at lower depths of the model. The model gives us a perfect radargram even at high depths of signal penetration, which is not the case with in-situ testing. Furthermore, radar is not a continuous measurement along a survey line. The system takes readings (scans) at a set spacing. If the scan spacing is too wide, there exists a risk of not hitting the desired target with enough scans which can result in a distraction within a scan, or worse, it could miss the target completely. Generally a minimum of 10 scans is needed to draw a recognisable hyperbola. The rule of thumb [24] is to have 10 scans divided by the depth of the shallowest target. Using lower frequencies requires coarser scan densities.

In complex, heterogeneous environments, the evaluation, interpretation and analysis of ground-penetrating radar (GPR) data is often complicated by the influence of near-filled antenna coupling or induction effects, variations in antenna radiation patterns, the presence of inhomogeneous, anisotropic and loose materials and the inevitable 'survey error' that arises during data collection [23]. These complexities can make data interpretation a hit-and-miss affair and unfortunately many of the advanced signal processing analysis methods are poorly suited for use in a complex, near surface environment.

Furthermore, GPR is a preferred method to identify voids and cavities in the ground around the tunnel lining.

Conclusion

GPR has the potential to non-destructively identify or differentiate grout once it has begun to set, a process which occurs rapidly due to the addition of accelerators to ensure rapid support of the ground around the excavated tunnel. Furthermore, GPR is a preferred method to identify voids and cavities in the ground around the tunnel lining. In order to test and further develop a GPR antenna and its performance, the knowledge and understanding of signal propagation through different media as well as the difference in material dielectrics needs to be further analysed.

The future focus of research is to further develop a GPR application in tunnelling, investigate the possible unknowns in dielectrics and most importantly to investigate a possible correlation with multiple non-destructive devices in order to overlay or strengthen the electromagnetic signal reflections. This research will involve further investigation of potential new combined GPR equipment, which would be dragged along the crown of the machine (+- 30O), to rapidly identify any disturbances (e.g. cavities, over-excavation, geological faults, poor grouting, water ingress, etc.) that would facilitate the machine's immediate re-injection or stronger grouting. The rectification of TBM's integrity is proposed to drastically reduce or even abolish the need for drilling through the segment and the use of secondary grouting.

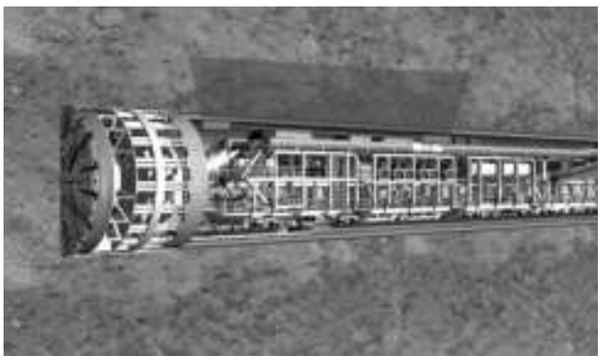

Figure 9: Proposed new online combined GPR equipment, which would be dragged along the crown of the machine (+- 30O) (modified from [11]).

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Doyles Creek underground mine

The conceptual plan, revealed in community consultations and canvassed at the recent annual meeting of Nucoal Resources, is to build a 500 metre tunnel under the Hunter River to join the Doyles Creek underground mine with the proposed Plashett open cut.

In Sydney last month, Nucoal's chairman, Gordon Galt, told a small group of shareholders about the so-called northern transport option: ''The key thing … is obviously, how does the government feel about having a tunnel under the Hunter River? It's not uncommon to have tunnels under rivers, or harbours, as the case may be, so we don't see that as an issue, but it will undoubtedly take them a little while to work their brains across the issue and progress it.''

Nucoal says there are environmental advantages to the plan, compared with a conveyor over the river, or an alternative ''southern transport'' trucking option.

There is a precedent; a 4 kilometre tunnel under the Hunter River at Anglo's Dartbrook mine, near Aberdeen, was built in the 1990s — although more groundwater flowed into the mine than expected.

Macmahon wins Olympic Dam underground services

Macmahon Holdings has received a A$200 million extension from BHP Billiton for the cornerstone Olympic Dam Underground Development Services contract.

The new three year extension will see Macmahon continue its current activities across the largest underground mine in Australia and also continues the company's long-term business relationship with BHP in South Australia that started in 2004.

Macmahon's contract includes underground development works, the installation of ground support including shotcreting and cablebolting, and load and haul operations.

The contract is the sixth extension the company has received and underpins Macmahon's Underground business for the coming period and also includes a one year extension.

While BHP has shelved previous plans to expand Olympic Dam, the mining giant has also asked the South Australian government for a four year extension to October 2016 to get its planning right for a revised expansion plan.

Pike River mine disaster

Mine disaster preventable

In October 2012 the report of the Royal Commission was released. The report found that the Pike River mine disaster was preventable and caused by the mine being used before it was ready. The report came close to two years after the disaster.

The Commission found that Pike River's "drive for coal production before the mine was ready created the circumstances within which the tragedy occurred". Reports of excess methane and other health and safety issues, including 21 reports of methane levels reaching explosive levels, were ignored for months, the Commission stated.

Poor drainage and ventilation systems were also highlighted, with the report finding they "could not cope" with everything that company was trying to do including driving roadways through coal and drilling into the coal seam.

The damning report also pointed to poor management of the mine and found the company's board of directors did not ensure health and safety was properly managed.

The report handed down sixteen key recommendations for tighter regulation and a greater focus on workplace safety across New Zealand.

Prime Minister John Key has apologised to the families of the lost miners, conceding the regulatory environment was not adequate.

It is expected all of the sixteen recommendations handed down will be enacted by the Government.

Another three coal projects ditched

BHP Billiton has added three new names to its growing list of shelved coal mine projects as it defers its Red Hill and Saraji East coal projects. The miner has also stopped research into its underground coking coal mine near Moranbah, where it had planned to mine 14 million tonnes of coal annually. The project was expected to cost the company more than $3 billion, given average industry project costs.

BHP blamed falling coal prices and weaker Chinese growth expectations for this decision, which follows the cancellation of plans to expand its Olympic Dam copper and gold mine in South Australia, as well as its Port Hedland iron ore harbour expansion in Western Australia.

Rio Tinto also announced more job cuts across its coal mines in Queensland as the State has raised its royalty rates and the commodity's price continues to fall.

Mine boss in court

In October 2012 the Pike River coal mine's former chief executive pleaded not guilty to health and safety charges laid after the New Zealand mine disaster.

Twenty-nine men, including two Australians, were killed when a series of explosions rocked the underground mine near Greymouth on the South Island in November 2010. As chief executive of Pike River Coal, Australian Peter Whittall became the public face of the mining tragedy.

Whittall appeared in the Greymouth District Court in October with his counsel, who on Whittall's behalf entered pleas of not guilty on all 12 charges. Whittall's lawyers said in a statement that he would fight the allegations "with all the means at his disposal. He has been a coal miner all his life. He relates to, and identifies himself with, coal miners," the statement said. "He would never do anything or take any decisions which would endanger those with whom he worked."

Whittall is accused of failing to protect workers in regard to methane, strata and ventilation management. The case is planned to return to court in March 2013.

In July 2012, Australian drilling company VLI Drilling pleaded guilty to three health and safety charges relating to the maintenance and operation of its drill rig used at the Pike River mine. The company said the charges did not relate to the disaster itself but instead to its failure to have a procedure in place to verify that Pike River Coal had conducted inspections of its drill rig.

OZ Minerals plans new decline at Carrapateena

OZ Minerals will sink a $110 million, 1 kilometre deep exploration decline at its Carrapateena copper and gold project in SA to aid exploration and mine design.

The Carrapateena project is located in central South Australia on the eastern margin of the Gawler Craton, 130 kilometres from Port Augusta, and 100 kilometres south east of BHP Billiton's Olympic Dam operation and 250 kilometres south east of OZ Minerals' Prominent Hill operation.

The company was considering a vertical shaft, but has opted for the decline a sloped underground road which trucks can be driven along, because it could eventually be adapted into the overall mine design. "The decline will allow access for OZ Minerals to assess the in-situ rock structures and competency ultimately providing an increased knowledge of the deposit," the company said in its quarterly production report. This will also provide necessary data through to feasibility studies to determine the best mining technique for this deposit."

Subject to receipt of all necessary permits and clearances, phase one of the decline is expected to commence in early 2013 and will be developed to a depth of approximately 625 metres by mid-2016. The second phase of the decline will extend down to approximately 1000 metres to undertake further exploration and geotechnical studies.

OZ has previously said it aims to make a decision to mine at Carrapateena by 2015, allowing it to bring the project into production before its Prominent Hill mine, also in the State's far north, is wound down in 7–8 years time.

Seismic event evacuates WA mine

No one was injured when a small earthquake caused a rock fall at one of BHP Billiton's underground nickel mines in Western Australia's Goldfields on 7 October 2012.

All staff were safely evacuated despite a power outage, the mining company said. Geoscience Australia reported a magnitude 3.0 earthquake near Leinster at 11.20pm (WST) on Sunday 7 October.

BHP Billiton said the seismic event resulted in a rock fall at its Perseverance underground mine about 10 kilometres north of Leinster. "No one was injured and all employees were accounted for," the company said in a statement. "Contact was maintained with all our affected employees and contractors at all times."

Rio Tinto to automate Argyle underground mine

Rio Tinto will deploy a sizeable automation system in its Argyle Diamonds underground mine in Western Australia.

The mining giant has committed to an AutoMine system made by Swedish giant Sandvik Mining.

The system includes 11 LH514E electric loaders and two LH410 diesel loaders that will be operated remotely from a surface control room, and associated software systems.

The Argyle mine will be the first in Western Australia to use block caving, which according to a Rio Tinto statement "involves the controlled collapse of ore from under its own weight, into specially-designed chutes for collection".

Block caving is expected to extend the life of the Argyle mine "until at least 2019". The mine had been an open pit operation, before Rio Tinto decided to build an underground mine below the existing pit operation in 2005. The miner put $US803 million ($787 million) into the transition in September 2010.

Sandvik Mining expects to deploy its automated systems into the underground mine in 2012–13. The system is expected to enhance safety, underground operational efficiency and production.

The Argyle deployment also represents several milestones, notably being the "largest underground mining automation installation in the world to date". "This order is a very important milestone in the growth of our fleet of AutoMine not only in Australia but globally as well," Sandvik Mining's vice president of mine automation Riku Pulli said.

The underground block-cave project is large and complex, requiring more than 40 kilometres of tunnelling.

New SA copper and gold mine opens

A new underground copper and gold mine has opened in South Australia's north, creating more than 150 jobs.

Premier Jay Weatherill opened the Ankata mine which is part of Oz Minerals' Prominent Hill operations. Mr Weatherill said the new project was an example of how companies could share the benefits of the mining boom, with 80 per cent of the workforce living in South Australia. "OZ Minerals also runs many programs aimed at educating their employees," he said. "It has funded many community programs aimed at breaking the cycle of social disadvantage and also mentored Aboriginal business owners."

OZ Minerals managing director Terry Burgess said the Ankata mine was a highly valuable addition to its Prominent Hill projects.

The company has spent $148 million developing the site and annual production was expected to reach 1.2 million tonnes by the end of 2012.

New Illawarra Mastermyne contract

Underground contractor Mastermyne is set to defy the industry gloom and announce a major drivage contract in the Illawarra region of New South Wales.

Mastermyne is seeking to expand its presence out of Queensland's Bowen Basin and into the Illawarra and Hunter regions of NSW. Mastermyne has a development contract with BHP Billiton's Dendrobium mine. The project scope for this contract includes the manning of one development unit to undertake scheduled development.

The works extend to the roadway advance in the main headings and carry out development works in the gate roads depending on the client's production requirements.

BHP Billiton last year announced the $US845 million Illawarra Coal — Appin Area 9 project, which will sustain the West Cliff and Appin mines for 20 years with capacity of 3.5 million tonnes per annum.

A new contract in the Illawarra would be a boost for Mastermyne, which announced in November that Centennial Coal had deferred its Newstan drivage contract.

Block Cave Mining Centre at North Parkes

Rio Tinto and the University of NSW has opened a world-first training facility in central western NSW where the next generation of mining engineers can learn the trade in a virtual environment.

Engineers at the Block Cave Knowledge Centre learn to drive massive boring machines on moving consoles and read mineral data in rooms that simulate the underground walls of a mine.

Copper is often mined using block caving, a technique in which copper deposits are carefully collapsed under their own weight. North Parkes was the first mine in Australia to use block caving, starting 15 years ago," said Stefanie Loader, the mine's managing director. ''Since then we have refined the method and it is now in its third generation… which makes our mine an ideal location for a state-of-the-art training complex." More than 50 people work in the centre.

Though projected to be the dominant form of copper mining by 2020, block-cave techniques are not well represented in university engineering courses. So Rio, a company hungry for employees to staff its five block-cave mines globally, is delivering its own training. The company plans to use the research centre to lead technological advances and overcome the national shortage in mining skills.

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ERA near deal to extend uranium mining

Energy Resources of Australia has begun laying the groundwork for extending the life of the Ranger operation inside Kakadu well beyond the current 2016 life estimate, with a modern mining agreement with traditional owners central to its investment plans.

Discussions started with the traditional owners on the renewal of the Ranger Project Area Authority in 1998. Concluding a mining agreement that gives the Mirarr people greater benefits from mining will give ERA the confidence to make the investments required to extend Ranger's life. The mining agreement is very close to completion after 14 years of discussion.

Production at Ranger is currently scheduled to come to an end in 2016. But ERA is about to start work on a $120 million tunnel to access 34,000 tonnes of uranium sitting deep beneath the Ranger 3 open-cut, which finished production at the end of 2012.

A $57 million pre-feasibility study in to the development of the so-called Ranger 3 Deeps is due to be completed in 2013. The underground mine could be in production late in 2015, ensuring Ranger continues as Australia's longest continually-operated uranium mine.

ERA has commenced its statutory approval process and hopes to start operations within 2 years. Chief executive Rob Atkinson says ERA has submitted plans to the federal government and the Northern Territory Environment Protection Authority for assessment. "Those will then provide us guidelines for the next stage of the approval process," he said.

A 2 kilometre tunnel, 300 metres underground, would replace the existing open-cut Ranger uranium mine.

Environment Centre NT spokeswoman Cat Beaton is calling for a full environmental impact statement on the proposed underground mine.

Xstrata Zinc — Hard Rock Mine of the Year finalist

Xstrata Zinc has been nominated as Australia's Hard Rock Mine of the Year. Operating since 1920, the mine has seen a number of developments as it works one of the largest zinc deposits in Australia. It has an annual production capacity of 300,000 tonnes of zinc concentrate and 170,000 tonnes of lead, and employs approximately 1,160 people.

One of its major focuses is integrating itself within the community and promotion of the Mount Isa region.

One of its major works has been its comprehensive study into promoting the town and bringing Mount Isa closer together with its operations. Dubbed the My Isa Study, it was an analysis of the needs of the mine's employees and their families in Mount Isa.

Regarding its employees and families as a distinct community it found that by supporting the greater liveability of Mount Isa it would help its employees as well as the broader community. The outcomes of the study are shaping its current and future strategies in relation to human resources management, community relations, and regional development.

Xstrata Zinc is now focused on increasing the quality of life in the region, promoting its attractiveness, and solving the housing issues that afflict many regional mining towns.

Explorer sues Newcrest

Newcrest Mining says it will vigorously defend itself against four legal challenges that threaten part of its $2 billion plans to build Australia's largest underground mine.

Private explorer, Gold and Copper Resources (GCR) has sued Australia's largest gold producer four times in two years in a David versus Goliath struggle. The latest claim was lodged in the NSW Land and Environment Court in November 2012. It accuses Newcrest of extending a tailings dam at the Cadia East site on to land where no mining lease is held, along with a slurry pipeline and pumping station.

The companies share borders in the Cadia Valley in central western NSW. GCR's founder and managing director, Brian Locke, has taken on corporate giants before, previously suing investment bank Macquarie and the case was settled in 2003. Mr Locke, who is also a farmer, accused it of breaching a confidentiality agreement and stealing the business plan that he took to them to irrigate desert area in southern NSW and grow wheat crops.

It accuses Newcrest of extending a tailings dam at the Cadia East site on to land where no mining lease is held, along with a slurry pipeline and pumping station.

The other legal battles against Newcrest involve more disputes about the awarding of exploration licences and a breach of confidentiality in the NSW Supreme Court about GCR's induced polarisation exploration technology.

Newcrest said it believed none of the claims had merit and it would be vigorously defending each of the court actions. "GCR has holdings of exploration licences in the Cadia district. GCR is seeking to expand those holdings, including by challenging existing Newcrest exploration tenure in the region," it said.

The expansion of its operations in the Cadia Valley are a crucial part of the company's future, with Newcrest expecting Cadia East will add 800,000 ounces of annual gold production to its current 2.3 million ounces. It said the legal matters were not material to day-to-day operations at Cadia including the start of production at the new underground mine.

Proximity detection

Queensland has backed away from mandating proximity detection systems in its mines. When Queensland said it was going to mandate proximity detection systems for its mines, it threatened to generate a seismic shift in how mining operations were managed. Proximity detection systems provide a safety net to prevent collisions between vehicles or, even worse, vehicles hitting people. However, the government backed away from demanding all mines have these systems in place.

Queensland Department of Natural Resources and Mines deputy director-general Stewart Bell said an issue it faced was that the State's underground coal miners were having problems getting systems approved for use underground. He said there were only a couple of systems available that could be used in underground coal. There are far more systems available for surface and even underground hard rock operations. One of the problems is getting such systems made intrinsically safe for use in explosive environments, such as underground coal operations.

Interestingly, the US Mine Safety and Health Administration also is putting pressure on operators to take up proximity detection systems. There have been a few examples in the past 12 months of workers in the US getting pinned between mine walls and underground mining equipment. There are proximity detection systems available that can prevent these sorts of accidents. With one system, miners put a sensor or a radio frequency identification tag onto their helmet. The machine recognises the sensor and if the miner comes too close, the machine shuts down.

Bell said one of the things he had been happy to see had been the advent of systems using multiple technologies. These can include RFID tags matched to cameras, GPS, or radar devices. This reduces the chances of accidents because if, for example, the RFID tag fails there is at least one other backup technology to help identify the threat. Bell said some Queensland mines had been trialling proximity detection systems for three years.

Another aspect of proximity detection systems is that they can log when there have been near-misses. Bell said he had not seen any hard data on these but did have some anecdotal evidence. Bell said the cost of these proximity detection systems had fallen. The cost of putting some sort of proximity detection system on is very small when compared to the cost of the machine.

EXPLOSIVE COAL REDUCTION SYSTEM TESTED

Coal mining tragedies often dominate the news, with scenes such as Pike River's huge ongoing explosions, the blasts regularly seen across Chinese coal mines, and events such as Nymbodia grabbing everyone's attention.

The cause of these awful events is often linked directly to leaking, and subsequent ignition of methane gas inside the mines.

But what many non-coal miners don't realise is that the real killer explosions, which tragically can sometimes cause death and major destruction in underground coal mines, are only triggered by an ignition of methane gas.

The main lethal element is a subsequent coal dust explosion set off by the methane ignition which itself can be relatively small and of short duration.

Traditionally the preventative measure employed by many coal mines is to use stone dust barriers where the stone dust mixes with coal dust and mitigates, or prevents altogether, a subsequent coal dust explosion but this has proved not always to be 100 per cent effective in guarding against these events.

Consequently much research has been undertaken over the years to come up with a system which is more efficient in suppressing such dust explosions and much of this revolves around instantaneous automatic water spraying to suppress a spread of such an explosion.

Much research has been undertaken in the civil tunnelling sector on similar anti-explosion systems, although this has obviously not been in respect of coal dust events which can spread right throughout a mine's underground workings with the potential to cause widespread loss of life — not only from the effects of an explosion itself but from toxic gases and lack of oxygen which result.

BMT WBM, an Australian subsidiary of UK headquartered BMT Group , and SkillPro Services, also from Australia, announced that they have successfully suppressed a coal dust explosion using their Active Barrier prototype system in the CSIR's experimental tunnel in Kloppersbos, South Africa.

The companies say that his system could play an integral role in enhancing the future safety of coal miners.

Historically, coal dust explosions have been the number one cause of fatalities within underground coal mines and even today, despite the use of various passive counter measures, these explosions cause many deaths worldwide.

David Proud, Business Development Manager for BMT WBM's Machinery group comments: "Using a sensor to detect the approaching coal dust deflagration, the Active Barrier system successfully injected 120 litres of water within 250 milliseconds in order to suppress the explosion, as was predicted by BMT WBM's computational fluid dynamics (CFD) modelling. This is a ground breaking development — one which could help to mitigate the risks of coal dust explosions occurring in underground coal mines."

BMT WBM and SkillPro have been involved in this R&D project for several years with the financial support of the Australian coal industry research body, ACARP.

BMT WBM has been modelling the physics and chemistry involved in the entrainment, devolatilisation and combustion of the coal dust particles and the injection and vaporisation of the suppressant. CFD was also used to simulate a range of designs for the prototype suppression device, in order to arrive at a practical and reliable experimental unit. SkillPro designed the final test apparatus and managed the test programme.

The ACARP Underground R&D committee has recently awarded the SkillPro/BMT WBM team an excellence award for the research and development undertaken on the Active Barrier project.

David Humphreys, SkillPro's Manager of the Active Barrier project comments: "A zero harm approach remains top priority for mining companies and SkillPro and BMT WBM are committed to helping their customers achieve this through the development of a range of innovative systems such as the Active Barrier.

The success of this test programme is another huge leap forward and we hope that we can continue our R&D work to further develop this pioneering product."

WA gold mine manager wins Telstra Business Women's Award

The general manager of an underground gold mine who led the development of an engineering innovation with international potential for the safety of mineworkers has today been named the 2012 Telstra Western Australian Business Woman of the Year.

Julie Shuttleworth heads the Granny Smith mining and ore processing operations of Barrick Gold Corporation, the world's leading gold producer. A metallurgist with 18 years experience in the gold and copper mining industry in Australia and overseas, she also won the Hudson Private and Corporate Sector Award and the Nokia Business Innovation Award.

Since 2010, she has led a team of 700 people at the Granny Smith Gold Mine, located 950 kilometres from Perth near Laverton and Kalgoorlie. In 2013, she will drive the mine's multimillion dollar open pit project expansion.

Previously she ran a mine site with 2000 employees and also led Barrick's Buzwagi Gold Project in Tanzania from feasibility study to operating mine.

Raised in Pemberton in WA, Ms Shuttleworth confronted the difficulties mineworkers face in changing tyres on underground mobile equipment in confined spaces. Traditional methods have caused serious injuries and fatalities. She sponsored a project to develop a low profile tyre handler that removes the need for people to be around the tyre while it is positioned for changing.

She follows other mining industry leaders including Denise Goldsworthy in 2010 and Gina Rinehart in 2009 to win the accolade of Telstra WA Business Woman of the Year.

Waihi gold mine seeks underground extension

The company which runs the Waihi gold mine wants to extend its underground operations, and if approved it would see it be the first mine in New Zealand to tunnel directly under people's homes.

Forty properties sit directly over the proposed mine extension, which at its shallowest would be 130 metres below the surface and extend to 350 metres at its deepest point. But Newmont mine says there is no risk of subsidence to the land above. "For every truck of rock we take out of the ground we actually send one down underground to fill any cavities that we leave so we're incredibly confident," says Newmont mine manager Sefton Darby. "We back fill all the areas."

Because of that, Newmont guarantees no repeat of what happened in 2001 when a sinkhole opened up, after an old tunnel left by a previous mining company collapsed. But even though by law every new tunnel would have to be filled, real concern in the town remains. "I really feel for those houses that are going to be above it and what it might do to their property values," says Hauraki District Mayor John Tregidga.

Without the extension the mine will close in 2015 and 400 jobs will be lost. "Most of these guys who are employed here, [with] their skills there's not a lot of other avenues in New Zealand for them so you'd find you'd have a lot of Kiwis leaving," says the mine's underground manager Charlie Gawith.

Waihi has been a mining town for more than a century and some there are worried that if the mine goes the heart of the town will go with it. "It's a mining town and has been for many years, and I think it would have real economic effects on employment and on the rest of the town if mining wasn't going to continue," says Mr Tregidga. It's set to be a long drawn-out process to see if the life of not just the mine, but Waihi itself, will be extended.

Production begins at Lady Loretta Mine

Xstrata Zinc announced that it has started ore production, which is well ahead of the actual scheduled date, at the Lady Loretta mine located in Northwest Queensland, Australia. Initial delivery of lead-silver-zinc ore will happen shortly.

The company is advancing the production and also developing the underground mine that contains lead, silver and zinc. In mid-2013, Xstrata will commence commercial mining at the Lady Loretta mine and complete production has been calculated to be 1.2 megatonnes of ore annually. This commercial mining program is anticipated to deliver net increase in the yearly zinc production of 20 per cent for Mount Isa operations. In addition, 230 permanent jobs can be generated upon full-scale production.

Xstrata Zinc Australia's COO, Brian Hearne stated that this project gains significance in the company's production profile and the early start of production ahead of the planned date is indeed a great success.

The Lady Loretta deposit includes a reserve of approximately 12.7 megatonnes which comprises 4.8 per cent lead and 14.2 per cent zinc grade along with 84 grammes per tonne silver. The amount of lead and zinc metal contained is calculated at 610 kilotonnes and 1,803 kilotonnes respectively, over 12 years of mine life.

The company has started the Lady Loretta project construction, 140 kilometres towards the north western part of Mount Isa during July 2011. The initial ore production at the project was expected to begin by end of 2013. Later, a decision was made in May 2012 to speed up the mine development by expanding the upper ore bodies of the deep underground resources and raising the production rate of ore from 1.0 to 1.2 megatonnes per year.

The ore taken from Lady Loretta will undergo primary crushing on site and will then be sent for processing to the company's Mount Isa complex. Later, this ore will be mixed with the ore obtained from Handlebar Hill Open Cut and Black Star Open Cut mines and the George Fisher underground mine. The high-grade ore from Lady Loretta can potentially increase production of metals and average grades, and help enhance cost efficiencies in the North Queensland business.

The company will shortly complete the construction of office buildings for administration and mining team.

Cost-effective method to determine thickness of passive fire protection for existing concrete structures

Nowadays it is a problem to determine the right amount of passive fire protection for existing concrete structures in order to prevent concrete spalling. This is mainly the case for renovation projects. Due to fact that concrete spalling still is an unpredictable phenomenon, literature study will not help for those cases. Efectis has developed a verification tool which enables us to determine the most economic thickness of a certain product which is suited for the application.

Efectis can test a small part (i.e. 1x1 square metre) of the concrete structure in-situ in real fire conditions (up to the RWS time temperature curve), using a mobile furnace. The mobile furnace is called the MobiFiRe(r) (see: www.mobifire.eu). As for existing concrete structures it is almost impossible to manufacture a representative concrete test specimen with similar constraints as in practice, an in-situ fire test seems currently the most economical and reliable option. There is a video on the website attached where a demonstration of such a test in a tunnel can be viewed. For building structures a much smaller mobile furnace is available (for ISO fire curve testing).

In order to determine the most efficient fire protection thickness Efectis developed special techniques using the mobile furnace, which does not require testing the product itself during the in-situ test. In that case standard (small scale) fire tests in the laboratory may be used to demonstrate the insulation capabilities of the product.

For manufacturers or applicators of passive fire protection the tool can be used as a unique selling point to independently demonstrate the right thickness for the specific application.

The Efectis Group is the European leader in fire science, engineering, tests, inspection and certification and gathers all the fire safety competences and experiences in testing and modelling in France, the Netherlands, Spain, Turkey and many other countries.

efectis group

New app for soil databases

Australia's national soil databases can now be accessed in real time online through a new iPad app called SoilMapp. The app provides quick open access to up-to-date information for soil at any location in the country.

The app has been developed by the Australian Collaborative Land Evaluation Program and CSIRO, with funding from the Grains Research and Development Corporation. Information such as soil depth, acidity, salinity, soil carbon, soil water holding capacity and other attributes will help land managers, farmers and underground infrastructure developers make decisions about how to effectively manage their land.

CSIRO's Mike Grundy said that SoilMapp will be of interest to people with infrastructure challenges but two additional components need to be added. "The web application at www.asris.csiro.au will allow you to look over the whole area of the infrastructure or along potential trench paths," Mr Grundy said.

"The other dimension is to then talk to the key contacts in that State — the web page www.clw.csiro.au/aclep/ has contacts for all States and Territories. That will allow you to zero in on specific issues more effectively."

Self-healing Concrete

Whether we're talking about buildings, bridge structures, large scale dams or parking lots, concrete as a material is pretty much indispensable to the construction industry.

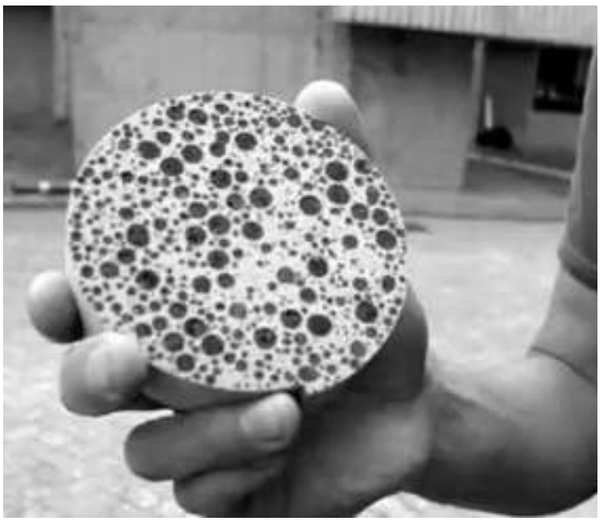
But it has one serious flaw: it has a low tensile strength and tends to crack when subject to tension. Even when reinforced by steel, concrete structures become vulnerable if exposed to water because tiny cracks on the surface allow water to seep in and corrode the steel reinforcement.

Because of this, engineers often use a larger than necessary amount of steel reinforcement within a concrete structure in order to prevent the cracks from becoming too large — excess steel which is not only costly but has no structural use.

Moreover, when concrete does crack, repair jobs can be difficult and costly, especially in environments where access to the structure is limited or in structures such as underground retainers for hazardous waste where human entry to conduct repair work involves danger.

A better solution, believes Dr Henk Jonkins, a micro-biologist at Delft University of Technology in the Netherlands, is to develop a solution which will allow the concrete to heal itself naturally.

Since 2006 Jonkins has been working closely with civil and structural engineers to develop a healing agent containing bacteria which are activated when coming into contact with water and convert nutrients into limestone which then solidifies on the cracked surface and fills it up.



Self Healing Concrete.

"We add to the concrete mixture a 'healing agent' which are particles composed of bacterial spores (dormant bacteria) and suitable feed surrounded by a coating" Jonkins explained recently to DesignBuild Source.

"The way the self-healing concrete works is that the occurring cracks break open the particles which release the bacterial spores and the feed in the crack. The incoming water activates the bacterial spores, converting them into active bacteria, which convert the feed into limestone. This process results in sealing (self-repair) of cracks."

Already, Jonkins says, the system has been tested successfully in the laboratory, and the team is looking to move into full scale outdoor testing in the coming year. Should these tests prove successful, Jonkins says he expects the system to become commercially available within the next two to three years.

On that subject, Jonkins says the commercial potential is substantial, especially in wet environments such as basement walls, underground parking garages, tunnels, water/liquid containers and infrastructure (e.g. viaducts) suffering from de-icing salts (chlorides from salts are very detrimental to concrete reinforcements).

Asked about the barriers the technology will have to overcome, Jonkins says his main area of challenge at the moment revolves around producing the agent at large scale at an acceptable level of cost. He says his team aim to produce the agent for 2–3 Euro per kilogram ($A2.44 — $3.65), which would equate to a cost of roughly 30–45 Euros per cubic metre of concrete mixture (15 kilograms of healing agent is applied per cubic metre of concrete).

At this level, he says the extra cost would pay for itself within the first 5 years in terms of costs avoided in terms of leakage and repair. Beyond that, he says, even more significant financial benefits would be derived through an increased life-span of structures.

The self-healing concrete project is part of a broader research program at the Delft Center for Materials into self-healing materials.

For now, concrete cracks when subject to tension. In a few years' time, should Jonkins and his team have their way, those cracks will heal automatically in newly built structures.

BEAM Geoelectrical Monitoring ahead of the TBM

BEAM is a non-intrusive focused-electrical induced polarisation ground prediction technique, permanently operating while TBM tunnelling.

Main components of the survey system are the measuring unit placed in the TBM operator cabin and special adapted excavation tools which are used as electrodes. The unit is connected to the guidance system and receives the boring signal which allows fully automatic data acquisition and visualisation in real-time on an integrated monitor. Communication facilities transfer the forecast results to every accredited computer world wide simultaneously.

Based on the measuring data the percentage frequency effect PFE and the resistivity R, an advanced evaluation software is established for geoelectrical-geological/ hydrogeological classification and interpretation.

Since 2000 the geophysical probing system is fulfilling the practical demands under the rough and various conditions of TBM tunnelling work by indicating reliable results in hard rock as well as in soft ground.

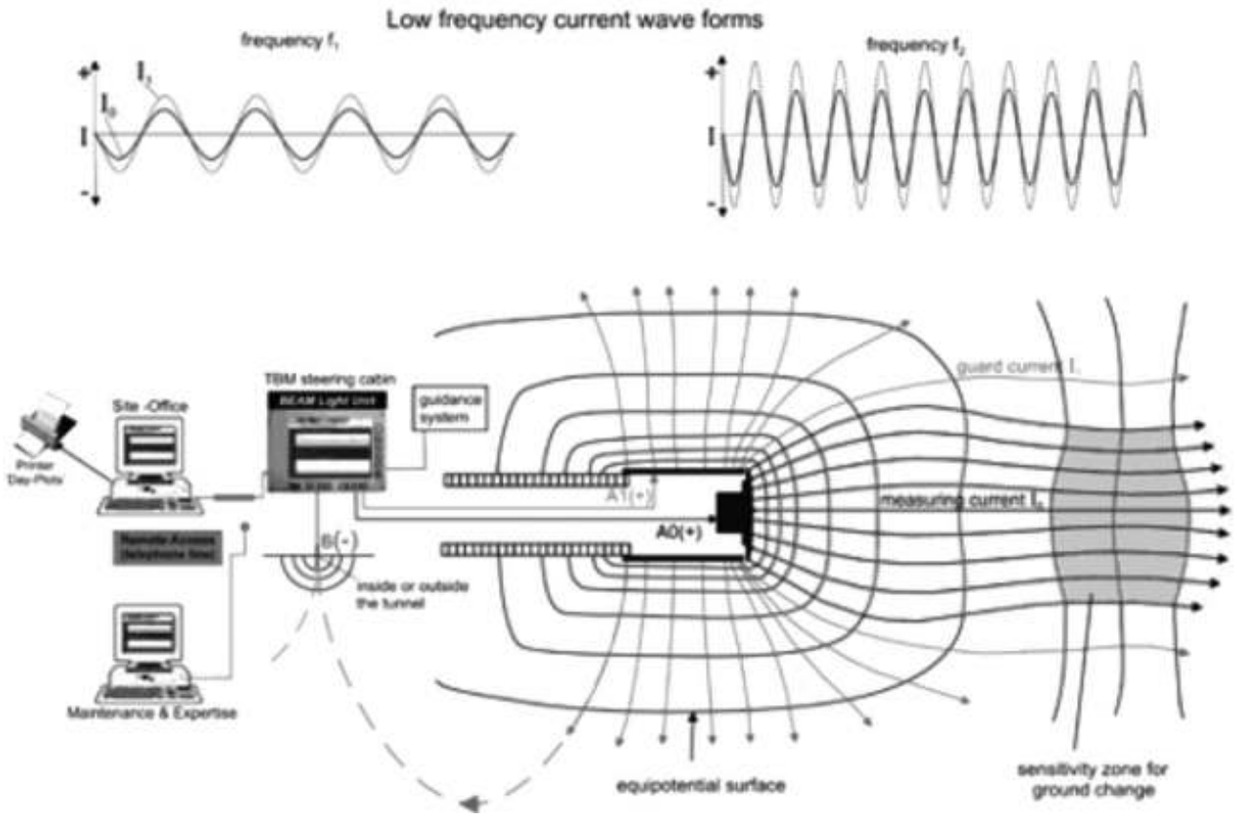
Early warning information of significant ground changes while tunnelling is advantageous to reduce hazardous risks, in particular during excavation with tunnel boring machines. Accidents or complications and hence expensive standstills can be prevented by planning precautionary and logistical measures.

On the condition that TBM operations and lining works should not be obstructed by data acquisition, a probing and documentation without pre-drillings is one major demand. On the other hand knowledge of non-critical ground conditions ahead of the face allows rapid excavation resulting in high production rates and contributes to shield staff and equipment.

The Bore-Tunnelling Electrical Ahead Monitoring — BEAM — developed and patented by Kaus et. al., managing director of GET, is a geophysical ground prediction technique especially designed for the underground construction industry.

Supplied on a rental basis by GET, it is increasingly ordered since the year 2000 to serve at international TBM projects with a total tunnel prediction length of more than 100 kilometres.

Beside the standard TBM operations, special applications has been performed for drill and blast drives and also perimeter investigations for cavity detection in karst formation around existing tunnels.



Method

BEAM combines the well established principles of focusing-electrode logging and frequency-domain induced polarisation (IP) measurements.

Low frequency alternating electrical fields are generated by galvanic injected currents through an excavation specific focusing electrode configuration.

By adjusting the same voltage of same polarity simultaneously between the guard electrode A1 (+) and the return electrode B (-) and between the measuring electrode A0 (+) and the return electrode B (-), the measuring current is forced ahead of the face, even if the electrode resistance between A0 and A1 is very low.

Therefore the realised constant measuring conditions of applied frequency dependent voltage U (f) and electrode configuration cause the magnitude of the sensed measuring current I0 (f) to be solely influenced by the electrical properties of the ground.

Thus, when the tunnel face is advancing towards a ground change, I0 (f) directly images the "coming" new geological situation.

The assessment of modelling results and geological experience from 28 tunnel projects with a total length of more than 100 kilometres, are indicating a distinct sensitivity zone for ground changes in a forefield distance of about 3 times the guard electrode A1 diameter, which is the tunnel diameter.

Petrophysical Classification

The induced polarisation expressed by the PFE characterises the ability of the ground to store electrical energy. It is caused by a variation in the mobility of ions in the pore and fracture space when an electrical field is applied.

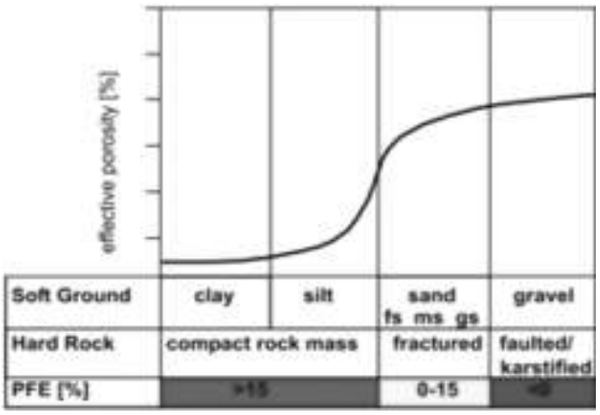
For example charges accumulate where pore or fracture throats are occurring and polarisation is based on ion transportation differences. Formations with small pores and tight fractures hold higher polarisation effects than formations with large pores, open fractures and cavities in karst formations.

Hence, it is a measure which is reciprocally correlated to the (hydraulic) effective porosity (permeability), which is a hydrogeological relevant property in hard rock and soft ground.

Additional information about the fracture/cavity infillings (e.g. water, loam, air) are obtained by the measured resistivity R.

From practical experience at different tunnel projects guided by BEAM surveys and correlation of geoelectrical PFE-data and R-data to the documented geological and hydrogeological conditions, a petrophysical classification was developed for soft ground and hard rock each with 12 types.

For tunnelbuilders in hard rock, the high porosity zones (type P1 combined with R1, R2 and R3) are driving relevant and those zones indicate critical rock sections,



e.g. fault and fracture zones, karst zones, water- and (methane-) gas-bearing zones and cavities. In soft ground e.g. sand/gravel aquifers, clay layers, pyroclastics, wood, boulders, piles and archaeological remnants are of interest for excavation.

The combined PFE-R-correlation matrix yields an advanced tool for geological and hydrogeological hard rock and soft ground characterisation.

Application

BEAM is most favourable applied in modern mechanized TBM headings, because all key benefits become operative as there are:

- full automated continuous data acquisition and processing
- real-time visualisation of geophysical measuring results and geological/ hydrogeological interpretation
- arbitrary data access from outside the tunnel

It can be used in any hardrock and soft ground and thus in EPB-, Slurry-, Gripper, Single or Double shielded TBM, independent from the manufacturer.

BEAM is sensing the induced Polarisation and thus the effective porosity changes in the ground. At the same time the measured resistivity is delivering the hydrogeological ground characterisation.

Thus the measurements are independent, if the obstacles or ground changes are found in soft ground or hardrock geology.

By the same reasons BEAM works also reliable if the exploration targets are to be located above or below the ground water table. In particular, if an EPB-TBM is boring below the ground water table, the BEAM-evaluation software is able to differentiate between a water-bearing aquifer (high permeability zones like sand/ gravel) and an aquiclude (low permeability formations like clay) as well as water- or air-filled cavities, clay-, sand-, silt-filled anomalies or archaeological remains.

BEAM® Perimeter

A special application option is the BEAM Perimeter survey around existing tunnels to detect karst cavities.

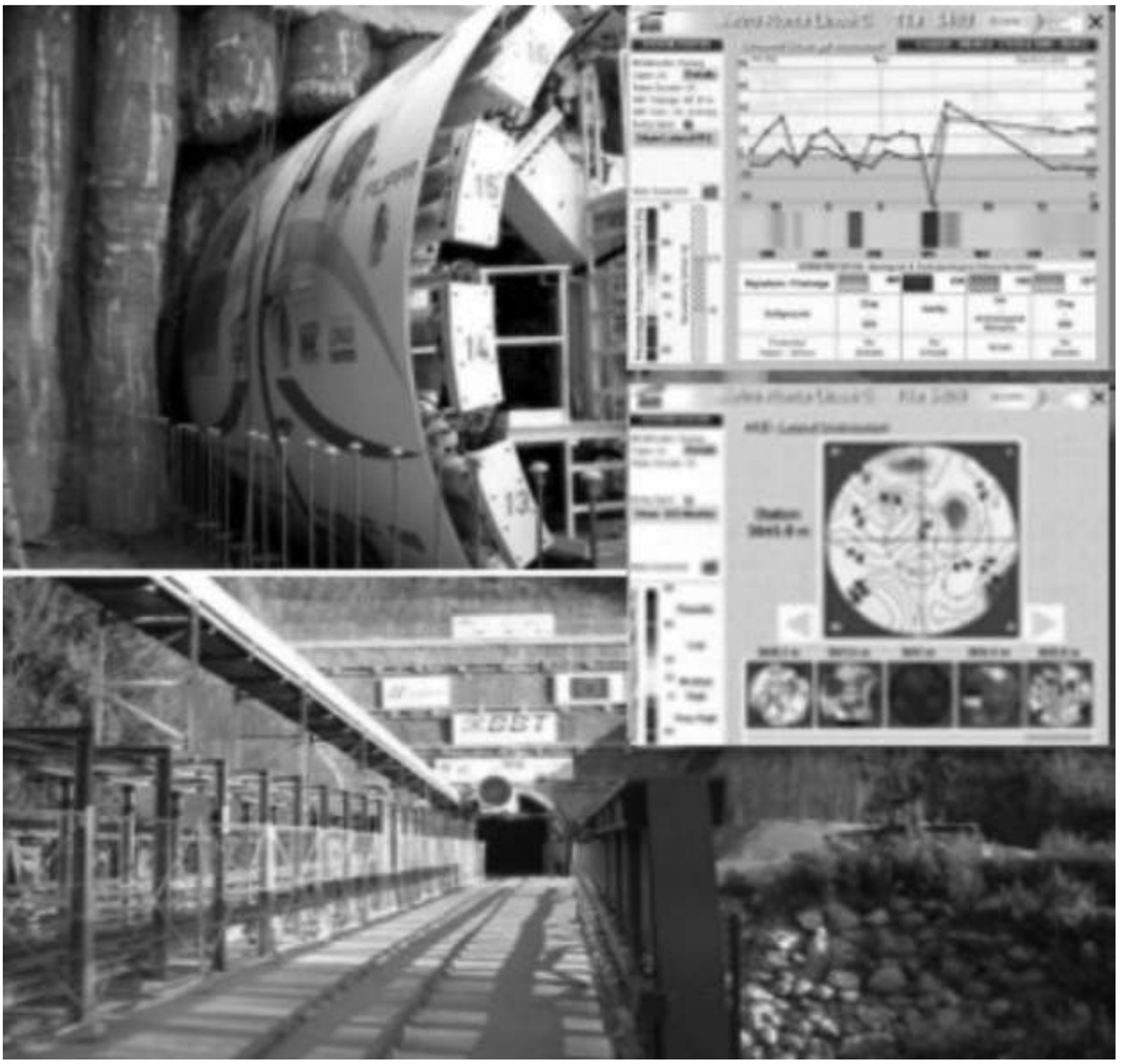
Visualisation

BEAM is based on an advanced in house developed processing, evaluation and visualisation software which shows the measuring data and distribution of percentage frequency effect PFE and resistivity R for geological classification and hydrogeological characterisation.

BEAM-INTEGRAL

The yellow line in the middle of the screen indicates the current face resp. position of the cutterhead of the TBM. Forecast results resp. survey points are "moving" strokewise from right to left whereby the red curve represents the PFE which characterises the rock mass regarding fracture/karst porosity information. The blue curve indicates the resistivity which provides information about the fracture/cavity infillings (e.g. water, gas/air, clay).

Unique feature of the software programme is a dynamic interpretation guide which has integrated the correlation matrix.



Every significant ground change ahead of the face is shown in a new text box with characterisation of rock mass types, signature and tunnel meter as well as an estimation of potential water- and/or gas-inflow into the tunnel.

BEAM-SCAN Visualisation

The Lateral PFE Distribution View is a feature only available with BEAM-SCAN system. Pre-selected excavation tools are prepared to act as measuring electrodes enabling a high resolution scan of the forefield ground during rotation of the cutterhead resp. cutting wheel.

The additional PFE lateral distribution can be used for more detailed characterisation and imaging the location and geometry of obstacles, cavities and ground changes.

With a button on the left side one may switch anytime between the Ground Change Indicator View (INTEGRAL-mode) with geological classification as well as hydrogeological characterisation and the Lateral PFE Distribution View (SCAN-mode).

BEAM is based on an advanced in house developed processing, evaluation and visualisation software which shows the measuring data and distribution of percentage frequency effect PFE and resistivity R for geological classification and hydrogeological characterisation.

FEATURES AND ADVANTAGES

BEAM is a robust and reliable long-term operating geophysical probing technique fulfilling the practical demands under the rough conditions of tunnelling work.

The summarised main advantages features are:

- Permanent automatic high resolution and non-destructive forward prediction while tunnelling;
- Early detection and warning of changes in geotechnical-geological and hydrogeological ground conditions like fault/karst zones, cavities or permeable water-/gas-bearing zones;
- Geoelectrical-geological/hydrogeological classification of forefield ground changes in real time visualised on the BEAM unit in the operator cabin and also on every other accredited computer in the world;
- Optimum planning of safety and lining measures in advance and with it in time to shelter staff, tunnel and boring machine;
- Realisation of high advancement rates without disturbance and stoppages of tunnelling work add to time reduction and cost savings;
- Detection distance ahead of the face amounts 3 times of the tunnel diameter;
- No percussion or core drilling is needed to use BEAM;
- Evaluation software comprising geological interpretation is self-instructional for tunnel engineers and miners job site;
- Applicable in hard rock and soft ground as well as above and below the ground water table;
- Implementation in any type of TBM independent from the manufacturer;
- Contribution to lowering risks and increased demands to occupational safety.

Thus the system could enable tunnel excavation to achieve particularly high advance rates, either due to improved confidence when it shows consistent ground conditions ahead of the face, and enable appropriate action to be taken when responses suggest more difficult ground conditions may be about to be encountered.

Big Trucks for underground mining

Caterpillar AD690 — Caterpillar has launched its new AD690 underground articulated truck. With a payload capacity of 60 tonnes, it is now the largest model in Cat's UG truck range, and provides nearly 10 per cent more in haulage over its previous AD55B. It incorporates advanced heat shielding and cooling technology, as well as the Car C27 ACERT engine to provide a better ride. The engine is rated at between 579 to 600 kilowatts has been refined for the AD60, and includes new pistons, high temperature fuel injectors, more durable rocker arm assemblies, ad redesigned crankshaft lubrication system, a high efficiency engine oil cooler, and a higher capacity fuel cooler.

The AD60 also comes with remote-mounted transmission oil coolers that ensure optimum operating temperature for the seven-speed Cat planetary powershift transmission, which features a lock-up torque converter for efficient, fuel-saving operation, as well as an electronically controlled retarding system for optimum safety and productivity.

According to Cat new features in the AD60 design include electronic integration of the engine and drive train, providing controlled-throttle shifting, overspeed protection, and body-up shift inhibitor. The now standard Truck Payload Management System calculates payload data, and the VIMS Guardian System provides operators, service technicians and managers with machine health information to ensure high mechanical availability. The choice of a dump or ejector body allows tailoring the AD60 to different applications, and the single-stage hoist cylinder speeds cycle times.

The frame design features box-section construction with materials and welding techniques that optimize structural life, and the articulation/oscillation hitch promotes stability and manoeuvrability in all types of ground conditions.

Sandvik TH500600 series — Responding to the growing demand of faster haulage, Sandvik has launched its latest additions to the TH500600 series, the TH551 and TH663 underground trucks. According to Sandvik "these new trucks demonstrate the latest innovations in hard rock ramp hauling, and are therefore the clear forerunners of next generation underground trucking". The new trucks have been designed to have the largest hauling capacity per envelope size, it added.

Following in the footsteps of the previously released TH550 and TH450, which cut diesel emissions, these new vehicles also have fewer emissions. The TH551 and TH663 have also been engineered to match Sandvik's LH517 and LH621 loaders. "This 'productivity partners concept' allows for a fast 3 bucket loading system, which increases the load and haul cycle efficiency, resulting in high levels of overall cycle productivity," the machinery company said.

Safety has also played a major role in the trucks' development. According to Sandvik they have more than 60 different safety features to protect the operator, maintenance staff and the truck itself. To assist in maintenance, particular attention has been given to the replacement time of large components, such as engine transmission, which in turn results in significant increases in uptime hours and the total of tonnes per year hoisted. Daily maintenance of the TH551 and TH663 can be done from ground level, minimising the risks related to climbing on the machine. These underground trucks also feature anti-slip materials on the steps and surfaces as well as the safety rails on top of the truck to add to personnel safety even in cases where climbing is required.

In the case of operator comfort, the ergonomic ROPS and FOPS certified cabin is now 35 per cent larger than its predecessors, offering features as 4 point retractable safety belt for the operator seat and 3 point safety belt for the trainer seat, MP3-player, cabin refrigerator and easy to use control system display with colour coded warnings, making it easier for the operator to concentrate on the work at hand — while still making sure that warnings are easily spotted.

100th Year of Tasmanian Mine Tragedy

Over one hundred years ago on 12 October 1912, Tasmania encountered its worst mining disaster when 42 miners died underground in the Mount Lyell mining tragedy. The town stood still to commemorate the centenary of the ill-fated event

Scores of descendants and families of victims, survivors and rescuers gathered in Tasmania's west coast community to commemorate the tragedy. Organisers held the memorial service at the site of the original shaft which has long been buried under tonnes of rock. The town and the people present during the commemoration all stood still, engulfed in complete silence, as sirens and church bells rang at 10:35am, the exact time the fire broke out 100 years ago.

Norma O'Brien, a granddaughter of Richard Treverton, one of the victims of the mining tragedy, said the experience "was very emotional, extremely emotional". Her grandfather could have been alive after the accident, but he chose to save others. "He gave up his place in the shafts that were going up. Then after that he wasn't able to get out himself," said Ms O'Brien, who travelled from Victoria to Queenstown for the first time just to be able to personally attend the commemoration of the tragedy's centenary. "We were always brought up that he saved many of the others' lives before he lost his own life. It was always a proud thing in our household."

Organisers led by Vedanta Copper Mines of Tasmania General Manager Scot Clyde said they have recreated the original funeral train, taking visitors and descendants to through the town cemetery. "A lot of people have made a great effort to be here today and we've been a bit taken aback by the strength of feeling and the appreciation of what we've done today with the memorial plaque, and having this service," he said.

The cause of the Mount Lyell mining disaster is still being questioned on the eve of its centenary. The fire which broke out in the North Lyell mine in October 1912 killed 42 miners and trapped about a hundred more underground. A Royal Commission delivered an open finding but the company accused an employee of lighting the fire. In a book written 50 years ago, historian Geoffrey Blainey argued that the fire was deliberately lit. "Not with the idea of causing death but with the idea of causing a shock," he said.

However in a new book about the disaster set for release this week, former MP Peter Schultz raises questions about the validity of blaming an employee. In an interview with 730 Tasmania, Schultz said he wants to set the record straight about the company's claim."They suppressed evidence of a number of electrical fires that had already occurred in the underground pump station," Schultz said. "The commission said there'd only been one electrical fire when there was evidence of five electrical fires and the pump station was extremely dangerous electrically. "There were no fuses in the control circuits and on two of the previous occasions where there had been fires; they had to switch off the power to be able to put the fires out."

Horseshoe Bend Diversion Tunnel 100th Anniversary

The Hannaford family celebrated the anniversary of 100 years of the opening of the Horseshoe Bend Diversion Tunnel on the Thomson River on the Saturday 17 of November 2012. The tunnel was opened on the 11 November 1912.

It all began back in May 1886 when a rich deposit of alluvial gold was discovered in the Thomson River at the Horseshoe Bend approximately 8 miles from Walhalla. Mr Woods of the Thomson Bridge Hotel secured the ground, but a company was needed to be formed to develop it. So in 1911 The Thomson River Alluvial Gold and Tailings Recovery Company began the diversion tunnel at Stockriders Spur. Progress of the distance achieved by the Company was detailed each week in the Walhalla Chronicle. After tunnelling through 400 feet, they struck hard rock. They decided to put out a tender in July 1912 and "Jack" (William John) Hannaford dug the last 200 feet.

The Hannaford family decided this amazing achievement of Jack Hannaford should not be ignored and organised a celebration of the 100 year anniversary of the Horseshoe Bend Tunnel. Many relatives and descendants travelled from Melbourne and various places from country Victoria, and to add character to the day, 2 of Jack's granddaughters Paulette Pizzari and Gwen Myers, and his great granddaughter Dianne Vapp dressed in period costume.

There were four guest speakers on the day, local MP Gary Blackwood who opened the proceedings, followed by local Councillor David Balfour representing the Baw Baw Shire, Martin Fuller CEO of the West Gippsland Catchment Management Authority, Kylie Debono Projects Managers of West Gippsland Catchment Management Authority, and an apology from Michael Timpano Regional Manager of DSE. Paulette Pizzari spoke of being a Gippsland girl and her love of the area and the protection of the environment at the Horseshoe Bend Tunnel and Gwen Myers spoke about the family history and the emigration of Samuel and his wife Emma (nee Gilbert) Hannaford with their 3 children, one sadly dying within days of arriving in Moonta, South Australia. Jack was born in SA in 1884 and was one of 12 children, 3 born in Devon UK, 8 born in SA and the last child Jim (Thomas James) being born on 25 November 1890 in Walhalla, Victoria. Jack had 11 children and the last surviving one being Ron Hannaford who is now in a nursing home in Bairnsdale and was unable to make the trip for the anniversary.

Martin Fuller and Kylie De Bono gave an update of the work being planned for the Thomson River and spoke of the importance of the connectivity of the Gippsland River System.

All attendees enjoyed a sausage sizzle, and a produce show bag which included the Hannaford/Gilbert cookbook, a key-ring featuring a photo of the Tunnel exit, pen, fridge magnet, local brochures regarding the area and what's on, a Hannaford pedigree chart with a photo of Samuel and Emma Hannaford (Jack's parents) information of what happened in 1912 and Newspaper extracts of the progress of the Tunnel. The cookbook has the history of the Horseshoe Bend Tunnel, the brief version of the family history, many family photos old and modern and of course recipes supplied by various family members.

Some of the group were able to walk down to the Horseshoe Bend Tunnel Exit and around to the Tunnel entrance.

All the people who stayed on over the week-end enjoyed a lovely meal at the Stockyard Hotel at Rawson, Saturday night. The next day kicked off with a visit to Walhalla, some took the train ride and most of the group visited the cemetery to view Samuel Hannaford's grave which now has a plaque erected by his descendants.

Monday morning, Paulette Pizzari, Gwen Myers, Andrea Myers and Gary Blackwood MP attended a meeting at the West Gippsland Catchment Management Authority in Traralgon to hold further discussions of the improvement of water flow back to the Thomson River. Recent Geo Technical reports have proved the tunnel to be very sound and has withstood the past 100 years well. The tunnel itself has an angle bend at the inlet which has probably helped lower the rate of erosion by the rushing water and also the construction of the Thomson Dam has lowered the waterflow considerably from what it was in 1912.

Construction of the Horseshoe tunnel

In June 1886, a rich deposit of alluvial gold was found in the Thomson River at the Horseshoe Bend approximately 13.5 kms from Walhalla. The land was secured by Mr Woods of the Thomson Bridge Hotel. The company, Thomson River Alluvial Gold and Tailings Recovery Company was formed but they didn't start working on the diversion tunnel until early 1911. They dug the first 433 feet of the tunnel and then struck hard rock. They decided to put the job out for tender and Jack Hannaford won the tender to complete the last 128 feet of the Horseshoe Bend Diversion Tunnel.

The Walhalla Chronicle and the Argus newspapers reported on the weekly progress of excavation of the tunnel in their Mining Notices. The Horseshoe Bend Tunnel was opened on the 11 November 1912 and diverted 97 per cent of the water from the Thomson River through the diversion tunnel. The dry river bed was then worked over thoroughly to recover the alluvial gold.

The only purpose of the diversion tunnel was to remove the alluvial gold and then abandon the site. The Horseshoe Bend Tunnel was built so well it has lasted 100 years and left an interesting relic of Victoria's gold mining boom.

Tunnel campaigner Bill Reid has dug out a small portion of one of the tunnels, but wants the Council to re-open the rest.

Campaign to re-open tunnels under Auckland's Albert Park

It's the dream of one man and it has gained support from thousands of people, Albert Park has never been a secret. But for 70 years, something has been hidden underneath. "These tunnels were built for 22,000 people as an air-raid shelter in case there was an air-raid from the Japanese in 1942," says tunnel campaigner Bill Reid." There are 3.5 kilometres of tunnels under Albert Park. It took 114 men just eight months to dig out. But after the war, they were sealed with more than 8 million clay blocks to ensure the tunnels wouldn't collapse."

Mr Reid has dug out a small portion of one of the tunnels, but wants the Council to re-open the rest, beginning with just one section for a museum and walk-way. "My life-long plan since 1986 is to get these tunnels open to the public of Auckland, tourists, and I'd like the descendants of the 114 tunnellers to talk into history."

A Facebook page started recently has already gained support from more than 6,000 people. There's also backing from an anonymous businessman who believes the tunnels can be developed into a cave for glow worms and even black-water rafting.

Auckland Council says given the historical value, there could be merit in exploring a partial opening of the tunnels for, say, a visitor centre. The Council says the next step is for Mr Reid to present his proposal to councillors and it will help him with his presentation.

"It's just a hidden, historical event that must happen," says Mr Reid. "It should happen. It should have happened a long time ago." And after more than 30 years of campaigning, he hopes the piece of wartime history won't stay hidden for much longer.

Australia's first road/tram tunnel

In 1842 James Mitchell commissioned a tram/road tunnel through Burwood ridge (now Merewether ridge). Known as "Mitchell's tunnel" the historical events surrounding its construction make it one of the most significant sites in NSW. It was partly due to the tunnel's construction that coal mining in Australia was opened up to independent mining, which in turn led to the Hunter's establishment as a coal-mining centre. It was also the first tunnel of its type to be constructed in Australia.

Mitchell publicly claimed construction of the tunnel was to allow access to Burwood Beach so he could build a salt works. In private, however, it appears Mitchell was planning to overturn the Australian Agricultural Company's (AACo) Government supported monopoly on coal mining. He had already approached Governor Gipps with several requests, including: that the Metallic Ores Act be repealed, allowing copper ores to enter NSW duty free; that Newcastle be made a free port so private vessels could enter the estuary without restrictions; and that he be permitted to mine and use coal from his estate as fuel for a copper smelter. Gipps agreed to the first two requests but felt he had no power to agree to the third.

Despite this set back, Mitchell continued with his tunnel project and commissioned its construction in 1846. It was constructed directly into a coal seam, located in line with present day Merewether Street. Work was carried out from both ends with the point of meeting marked by an obvious change in direction of the pickaxe marks. The roof was high enough to accommodate a horse team. Two to three thousand tons of coal were extracted, which Mitchell could do nothing with due to the AACo monopoly.

Mitchell floated the Newcastle Coal and Copper Company in 1854 and concentrated on coal and coke production, buying up the Burwood Ridge mining leases and introducing the latest technology by replacing the wooden tramroads with iron railways and the horses with steam locomotives. By 1858 the company was focused at one mine, the Victoria tunnel, but this became threatened by geological instability, so the company started the Red Head Tunnel on the southern shore of Glenrock Lagoon in 1861 and constructed a coastal railway to service it.

The railway roughly followed the Aboriginal pathway along Burwood Beach and included two tunnels through Merewether bluff, the first rail tunnels in NSW (dating from 1861 and 1862 respectively). The railway proved a costly exercise. The construction costs, conflict and court action between the company and the builder plus a miners' strike lead to the company's failure in 1864.

Photo shows the 1890s excursion to Merewether with the tunnel entrance next to the present day baths.

The two tunnels were dug through the cliffs under the present day Merewether Heights. The tunnels were used for many years by hikers and picnickers to Glenrock Lagoon before deterioration in their condition caused them to be sealed at their entrances during World War II.

The second tunnel came out of the cliff just behind the amenity block at Merewether Baths. A small steam engine called the "Coffee Pot" was used to haul coal along the line. The "Coffee Pot" was specially modified with a vertical boiler, altered chimney, and cut down cabin and with the driver one end and the fireman at the other, so it could pass through the tunnels to Merewether.

About 200 metres from the tunnel behind the Merewether Baths were located coke ovens owned by the Newcastle Coal and Copper Company which supported the smelter works situated in Murdering Gully which is not far from the second tunnel exit on the present day Hunter District Water Board property adjacent to Smelter's Beach.

The "Coffee Pot".

LOCATING GALLIPOLI'S TRENCHES AND TUNNELS

Almost 100 years after thousands of young Australian men died at Gallipoli, a scientific team is trying to unravel what happened.

The legend of Lone Pine began on day one of the campaign when the Anzacs first reached the ridge top and a few weeks later in May its place in the Anzac legend was assured when Albert Jacka was awarded Australia's first Victoria Cross. Not long after the small battlefield on the second ridge would be well and truly cemented into Australian history, with seven VCs awarded at Lone Pine.

By August, 1915, it was clear that the stalemate along the ridgelines between Lone Pine and Baby 700 could not be sustained. The trenches and tunnels at places like Quinn's Post were so close that the two sides could almost spit at each other.

The Turks advanced in a bold bid to re-take the trench and blew up the sand bag barricade, but three Victorians from the 7th Battalion re-built it and then re-built it again. All three men, along with another four, were awarded Victoria Crosses for their gallantry at the August battle of Lone Pine, making it the most highly decorated place in Australian military history.

Thousands of Australian soldiers have no known grave, but lie beneath the dirt of a beautiful Turkish peninsula far, far from home.

According to government historian Dr Richard Reid, the trench that generated the three VCs was located just behind where the Lone Pine Memorial now stands and probably beneath the road that carries hundreds of thousands of tourists to Gallipoli each year.

Today a joint historical and archaeological survey of Gallipoli by the Australian, Turkish and New Zealand governments is using modern technology such as GPS and ground penetrating radar and a bit of good old-fashioned, bush-bashing field work to piece together the story of a disastrous military campaign that forged a young nation's identity.

Ninety years after the event in 2005, the three governments agreed that until a detailed scientific survey had been carried out the full story of Gallipoli, and the men who fought there, would never be told. So now a dedicated team of 16 scientists and historians is unveiling the terrible story of Gallipoli's trenches, tunnels, pits and dugouts in painstaking detail.

Now in its third season, the survey is gradually piecing together a complete picture drawing on painstaking field work, historical maps and official documents and the diaries of the men who dug and lived and died in and above the trenches of Gallipoli.

While the survey team does not do any excavation or digging, it has managed to collect an array of war relics. The team occasionally finds a bone that might possibly be human and when it does the team leader, retired Rear Admiral and former Repatriation Commissioner Simon Harrington, conducts a small but dignified burial service with a Turkish official in attendance, to lay to rest what could be the remains of a soldier.

What were 2metre deep trenches are now mostly 70 centimetres or less indentations and the former network of man-high tunnels that criss-crossed many sites are visible only as slumps where they have given way or caved in. The extent and complexity of the tunnel system has surprised the team, but the amount of lead flying around above ground made life in the open air tenuous, so the only solution was to tunnel towards the enemy and to break out into firing positions.

The most terrifying tunnels are the deeper ones dug beneath enemy tunnels with the object of setting charges and destroying the enemy shaft and anyone unlucky enough to be in it at the time. The Turks did the same from the opposite direction.

Every piece of material the team collected, down to the tiniest fragment of shrapnel, is recorded and photographed. So far the count is almost 1000 exhibits. During this last year the finds have included Roman relics at Lone Pine, dating from 200AD.

Clearing a tunnel on the battlefield at Lone Pine.

COWAN BANK

The Cowan Bank is an 8.6 kilometre double-track section of the standard gauge main north railway line running between Sydney and Newcastle one of the busiest rail corridors in Australia. The Cowan Bank is situated between Cowan railway station 48.8 kilometre north of Sydney, and Hawkesbury River railway station 57.4 kilometre north of Sydney. It has an average grade of 2.5 per cent (1 in 40) rising from close to sea level at Hawkesbury River railway station to a height of 200 metres on the ridge top at Cowan railway station.

The Cowan Bank has 5 tunnels (of which 4 are still in use), no level or grade crossings and two road bridges. The line crosses under the Pacific Highway twice, once using a road bridge near Cowan station and again while passing through Boronia #1 tunnel. It crosses under the Sydney-Newcastle Expressway while passing through Boronia #2 tunnel. The line was built through very rugged and heavily forested terrain on the western edge of the Kuring-gai Chase National Park. Because of its isolated location there are very few places from where the track can be observed — sections of the Pacific Highway on the ridge between Cowan and the Hawkesbury River provide a few vantage points.

Bank engines were attached to the rear of trains at Hawkesbury River station to assist them in the climb and were detached at Cowan station. After assisting a train up the bank, the bank engine would usually return to Hawkesbury River station to await the next train. Bank engines are no longer used on the line.

Because of its long grade and proximity to locomotive manufacturing and maintenance facilities in both Sydney and Newcastle, the Cowan Bank is often used to test locomotives and power cars.

The single track line between Cowan and Hawkesbury River stations was completed in 1887. Five tunnels (Boronia #1 to Boronia #5) were built as double track tunnels but initially only a single track was laid through them. The line was duplicated in stages between 1907 and 1909. Boronia #5 tunnel was abandoned when the tracks were realigned during the duplication.

The Royal Melbourne Hospital tunnels

The original sections the RMH tunnels were built in the late 1930s and the newest tunnels built in the early 2000s to protect the operating systems for power, water, heating, cooling, oxygen and more. The hospital was also occupied by the US Army's occupation of the hospital in World War II and there were possible additional tunnels built under Melbourne during the war.

In the original tunnels a multitude of services exist, including the supply of power, water, oxygen and heating, as well as waste management, linen, cleaning staff, mail, IT, pharmacy, medical records, etc. The tunnels also link to the Royal Women's, Royal Children's, Melbourne University and the former dental hospital across Grattan Street.

The underground traffic tunnels were constructed in the late 1930s, when the new RMH was being built in Grattan Street, Parkville. At that time, they were 260 metres long, containing steam and service pipes, to transport washing to and from the laundry and goods from the stores section. More than 80 kilometres of pipes were needed for steam for sterilisation and internal heating and hot water. On a winter's day, 16 tons of water were needed to be converted to steam.

Unexpectedly, the tunnels were first used during World War II for patient accommodation for US soldiers — the US Army's 4th General Hospital occupied the newly built RMH for two years from March 1942 to March 1944, and used every available space to treat 35,000 wounded and sick soldiers from the Pacific during that time.

Mystery surrounds just where the tunnels extended to during wartime and whether they still exist — possibly as far as Victoria Barracks to the south and Mt Alexander Road to the west. A 750 metre tunnel under Flemington Road (perhaps originally part of a link to the US Army camp in Royal Park during the 1940s) was rediscovered in the 1960s and is used to supply steam to the Royal Children's Hospital (until the new Children's opens this November). This tunnel is very hot, cramped and only accessible via a 3 metre ladder. Consequently, it is not open to the public.

There have been many infrastructure changes since the hospital officially opened in 1944, such as reconfigurations of the tunnels, new technology, environmental initiatives, and much more. The hospital has 8 tunnels, with the latest built in 2001. The RMH tunnels are now also used to provide infrastructure services to the Royal Women's Hospital, which relocated beside the RMH in 2008, and will have a key role in supporting the new Victorian Comprehensive Cancer Centre across Grattan Street, which opens in 2015.

The RMH Archives Committee run regular exhibitions, with a display of architectural drawings and photos from the early years of the hospital, and former staff will be available to answer questions about the hospital's history. Visitors are welcome to visit the Historical Room and view the displays.

Mount Tarrengower Tunnelling Company

First compressed air rock drilling in Australia

The Maldon quartz reefing field, although relatively small compared to others in the State, was extraordinary rich in gold. The hardness and heavy mineralisation of the rock mined put the field's mining companies in the vanguard for the use of new technology.

This site contains the tunnel or adit excavated by the Mount Tarrengower Tunnelling Company. This company was the first in Australia to use compressed air-driven rock drilling technology. The subsequent widespread adoption of this technology was a milestone in Australian underground mining. The Mount Tarrengower Tunnelling Company commenced mining operations at Maldon in 1865. Their tunnel was designed to cut reefs at a greater depth than any workings in the colony.

That ambitious objective was hampered by the hardness of the rock, which made progress by tap and hammer very slow. In 1866, a Low's rock drill, manufactured at St Peter's Iron Works in Ipswich, was introduced. The company nonetheless failed to find payable gold and was wound up in 1870. The fate of the rock-drill is not known.

The Mount Tarrengower Tunnelling Company Gold Mine is of historical, archaeological and scientific importance to the State of Victoria.

The Mount Tarrengower Tunnelling Company Gold Mine is historically and scientifically important as a characteristic example of an important form of gold mining. Gold mining sites are of crucial importance for the pivotal role they have played since 1851 in the development of Victoria. As well as being a significant producer of Victoria's nineteenth century wealth, quartz mining, with its intensive reliance on machinery, played an important role in the development of Victorian manufacturing industry. The Mount Tarrengower Tunnelling Company's Gold Mine is important as a manifestation of this aspect of gold mining.

The Mount Tarrengower Tunnelling Company Gold Mine is a significant historic location where the first compressed air-driven rock drill in Australia was used. Although the technology did not prove successful in that instance, a decade or so later the rock drill revolutionised underground mining in Australia and, in doing so, reversed the fortunes of many a declining goldfield. The rock drill also brought a social cost in the form of the deadly lung disease, phthisis, known euphemistically as "miners' complaint".

The Mount Tarrengower Tunnelling Company Gold Mine is scientifically significant for its potential to yield artefacts and evidence which will be able to provide significant information about the technological history of gold mining.

Raurimu Spiral

The Raurimu Spiral is a single-track railway spiral, starting with a horseshoe curve, overcoming a 139 metre height difference, in the central North Island of New Zealand, on the North Island Main Trunk Railway. It is a notable feat of civil engineering, having been called an 'engineering masterpiece'. The Institute of Professional Engineers (NZ) has designated the spiral as a significant Engineering heritage site.

During the construction of the central section of the North Island Main Trunk railway between Wellington and Auckland, a major obstacle was faced — how to cross the steep slopes between the North Island Volcanic Plateau to the east and the valleys and gorges of the Whanganui River to the west.

South of Taumarunui the terrain is steep but not unmanageable, with the exception of the stretch between Raurimu and National Park, where the land rises too steeply for a direct rail route. A direct line between these two points would rise 200 metres in a distance of some 5 kilometres, a gradient of 1 in 24.

The area was thoroughly surveyed during the 1880s in an attempt to find a route with a lesser grade, but the only viable possibility seemed to require a 20 kilometre detour and 9 massive viaducts. Even then, the gradient would have been over 1 in 50.

Construction

The problem was solved in 1898 by R W Holmes, Public Works Department engineer. He proposed a line that looped back upon itself and then spiralled around with the aid of tunnels and bridges, rising at a gradient of 1 in 52. Though costly and labour intensive, the scheme was still cheaper than the previous plan by Browne and Turner which required 9 viaducts down the Piopiotea. Probably the most remarkable feature is that, even today, there is no place to view the complete line. By all accounts, Holmes visualised the layout in his imagination.

The railway forms an ascending spiral southwards, with 2 tunnels, a circle and 3 hairpin bends. From the north, trains pass Raurimu before going round a 180 degree bend to the left in a horseshoe curve, climbing above the track on which they have just travelled. Two sharp bends to the right follow, after which the line passes through 2 short tunnels. Trains then complete a full circle, crossing over the longer of the 2 tunnels through which they have just passed, before continuing towards Wellington. Two kilometres further on the line has 2 further sharp bends, to the right and then to the left. After the second of these bends a train has risen 132 metres and travelled 6.8 kilometres from Raurimu — the straight-line distance is 2 kilometres.

Legend has it that a train driver once emergency-braked his train in the night upon mistaking the light of his last wagon on a nearby part of the spiral as the rear of a different train directly ahead of him.

Freemantle Whalers Tunnel

Two whaling companies were formed in Western Australia in 1837: the Fremantle Whaling Company based at Bathers Bay and the Northern Fishery, also known as the Perth Fishery, which had its station on nearby Carnac Island. High profits were anticipated and the first year of operations was promising. In February 1838 however, the Perth Fishery ceased activities. This was due largely to crew inexperience, company mismanagement the high cost of operations and the difficulty of acquiring replacement supplies made necessary by accidents in nearby Cockburn Sound. The Fremantle Company continued to operate in 1838 and 1839 with export of whale products returning 3380 pounds and 3170 pounds respectively in each year. However, a drastic decline in overseas bone and oil prices in 1840 led to its closure and the dispersal of its assets.

Three years were to elapse before higher overseas prices made the resumption of whaling operations viable. The reopened Fremantle Company was joined by several smaller enterprises in the mid-1840s: Cheynes Whaling Station at Albany. Child's at Bunbury, and smaller organisations at Vasse and Augusta in the south-west with finance coming largely from single individuals. The result was that from 1844 to 1850 export revenues from whaling of 4000 pounds to 5000 pounds were the norm. Eventually, some 15 whaling stations were to operate on the Western Australian coast, from the Recherche Archipelago in the south to the Dampier Archipelago 1000 kilometres north-west of Perth."

The development of the petroleum industry contributed to a general decline in whaling activity in the 1860s. A report lamenting the days when a regular station was kept at Fremantle, appeared in the Inquirer in October 1865. The date at which whaling operations ceased at Fremantle is unknown but probably not long after this.

A sketch of the station, drawn by Horace Samson in about the 1840s shows a boatshed containing a whaleboat and a two-storey warehouse set up the 15 metre high cliff face. A rough stone and wood breakwater jetty, equipped with a derrick and a windlass for heaving whale carcasses or blubber ashore, is visible. The try works are not seen, although what appear to be try pots lie close to the boatshed. To the right of the Station House is the entrance to the whalers' tunnel.

This was constructed by the Fremantle Whaling Company to provide quicker access from the jetty to High Street. Using the services of Mr Reveley and the labour of Round House, the 57 metre long tunnel was cut in five months through rock that, although solid enough to bear any weight in its natural state was capable of being cut with a broad axe and pick. The work was completed in January 1838. It is possible that a detachment of miners and sappers, who were stationed in Fremantle at the time, may have assisted in the construction.

The Fremantle Company continued to operate in 1838 and 1839 with export of whale products returning 3380 pounds and 3170 pounds respectively in each year.

Rottnest Island Fortress

During World War II, two 9.2 inch guns were installed near the middle of the island at Oliver Hill, and two 6 inch guns installed at Bickley Point, for defence of the Fremantle port. The location of the island was seen as being important to the defence of the port of Fremantle, the major base for the Allies in the Indian Ocean, as bombardment of any attacking ships could be made from the island before the ships would come into range of the port.

A light railway was built from the jetty at Kingstown Barracks on Thomson Bay, to transport material and munitions to the guns. The military fixtures including the barracks and railway became known as the "Rottnest Island Fortress". A number of concrete lookouts and bunkers were built around the island also.

Near Wadjemup Lighthouse, a Battery Observation Post (BOP) was built as a lookout to coordinate aiming and firings from the Bickley and Oliver's Hill Batteries. A Signals Building, associated with the BOP and a Women's Army Barracks, built to house officers and staff who operated the BOP were constructed there also. The latter building is used nowadays for occasional accommodation for University and other scientific research groups working on the island.

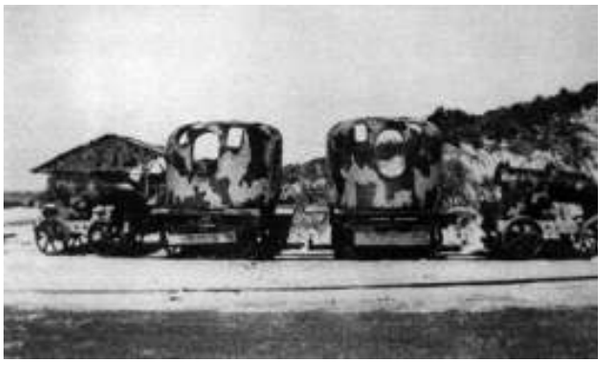
After World War II the guns and infrastructure were decommissioned and parts of the railway removed. The 9.2 inch battery, however, was saved from disposal because the high cost of removing and shipping the guns to the mainland exceeded their value as scrap metal.

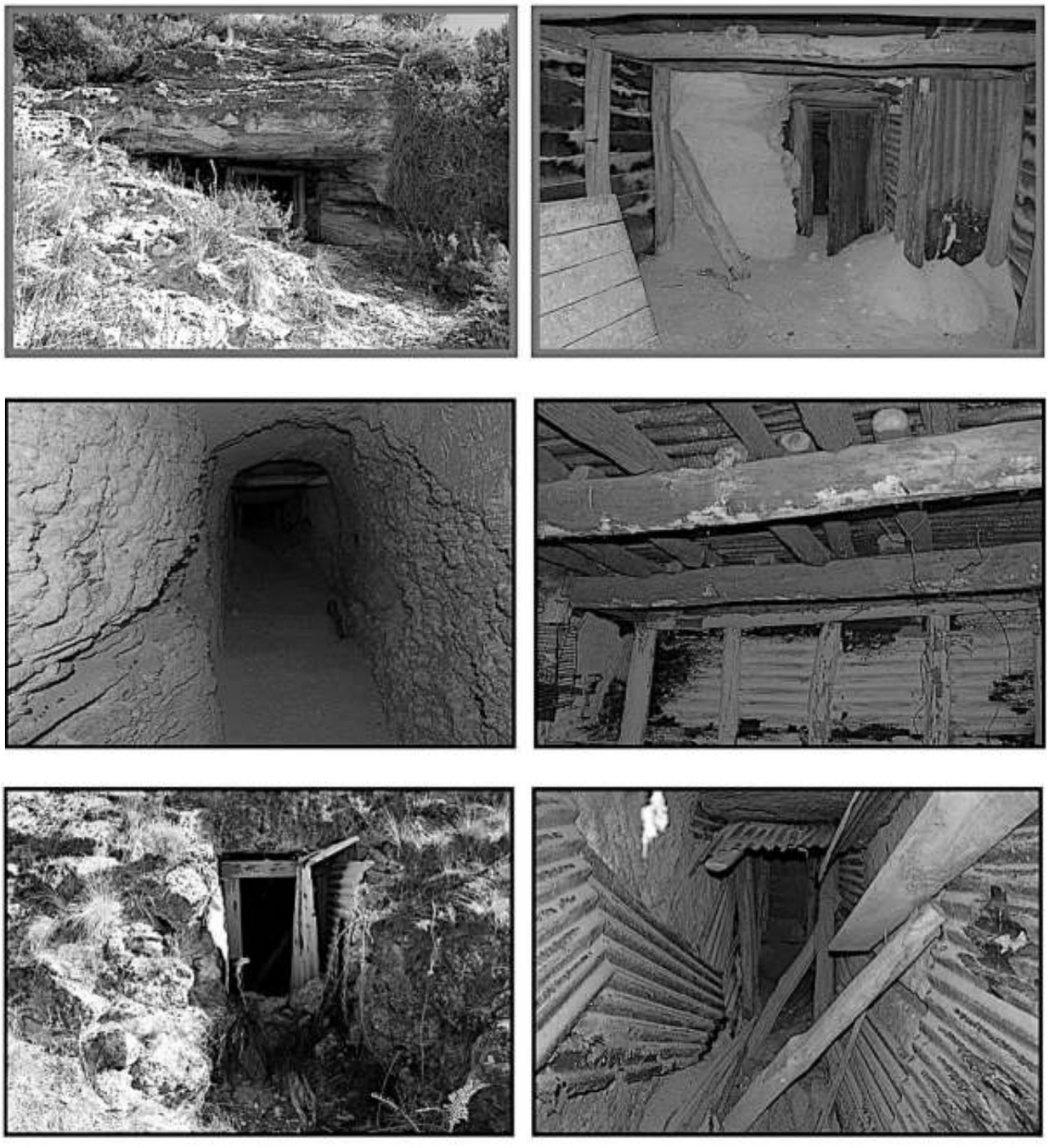
In the 1990s the gun emplacements and railway were extensively reconstructed and today a popular tourist activity includes tours over the guns and the tunnels with the journey to the battery being made on a purpose built train.

Many Island visitors enjoy the very interesting guided tours through the reconditioned tunnels and machinery rooms beneath one of the heavy wartime guns mounted atop Oliver Hill. They're an island experience which shouldn't be missed.

There are other tunnel systems and underground shelters elsewhere on the island which have not been refurbished, nor are they ever likely to be. Parts of them are potentially hazardous.

They exist as mute testimony to the courage and tenacity of thousands of Australian service personnel whom under arduous conditions defended the island and the approaches to Fremantle during the urgent years of World War II.





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New on the ATS website is a forum to allow members to discuss issues of importance or to seek advice from experts within the industry.

It's free to join – just register on the page

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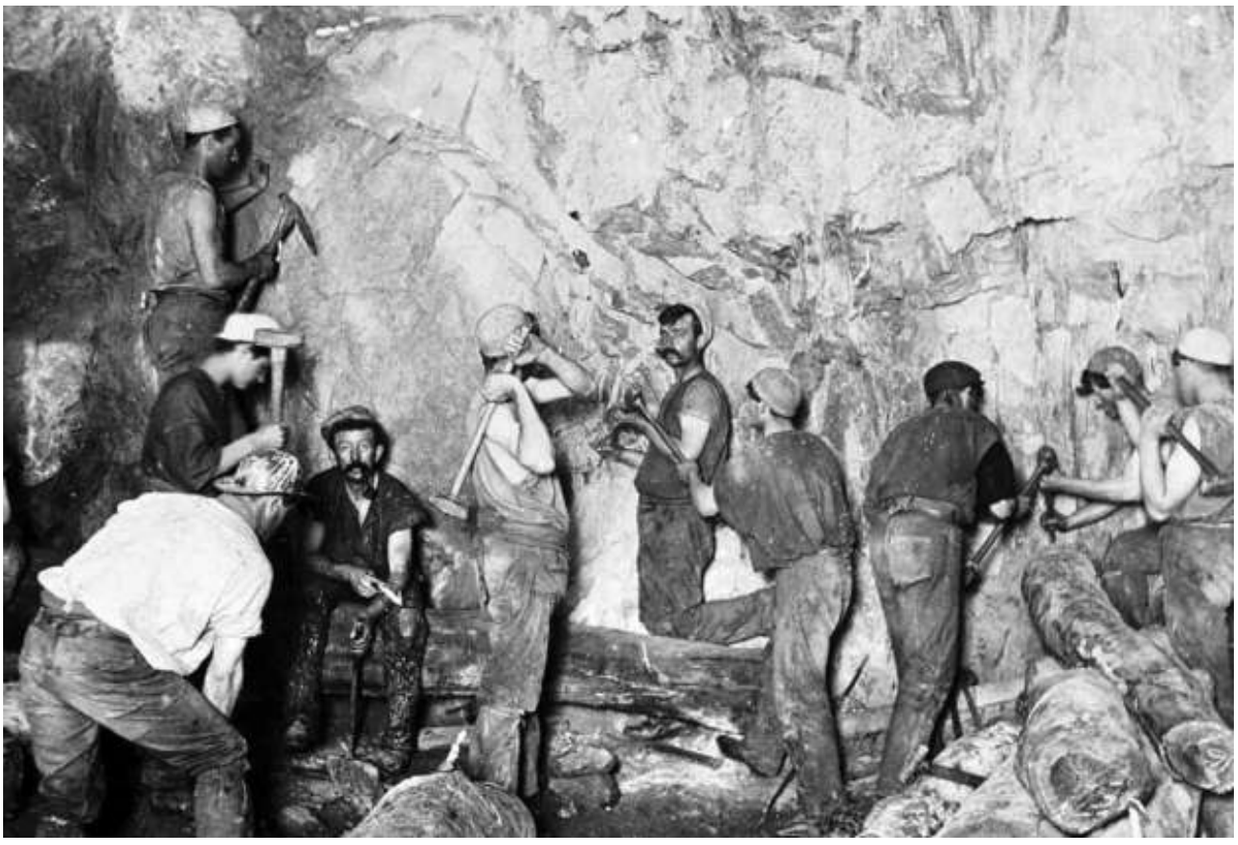


Hand drilling blast holes at Wallaroo Mines, c.1910.

19TH CENTURY COPPER MINING IN SOUTH AUSTRALIA

The first metal mine in Australia, Wheal Gawler at Glen Osmond, commenced operations within sight of Adelaide in 1841. However it was the mining of copper ores at Kapunda (1844) and Burra (1845), which aroused widespread interest in metal mining in South Australia and caused the first major decentralisation from Adelaide. Cornish miners and their families poured into South Australia to take part in the great copper boom. They brought with them their mining expertise to help extract the rich ore that gave South Australia the title of The Copper Kingdom by virtue of mines of world significance.

By 1850, South Australia was the third largest copper producer in the world and its mines had added financial stability to an almost bankrupt colony. These mineral deposits had a profound effect on settlement in the new colony. Land was surveyed for mineral tenements, mining townships and agricultural purposes. Basic road networks were established during this period to cart ore to Port Adelaide for shipment to Wales, and to deliver heavy machinery to the mines.

South Australia's importance as a copper producer was maintained with further discoveries at Wallaroo in 1859 and Moonta in 1861. These mines were on large, rich deposits and were worked continuously for more than 60 years. During the 1860s and 1870s, many smaller mines producing copper, gold, lead and silver were established throughout the Mount Lofty and Flinders Ranges.

Loading from an ore stope in a well timbered drive, Wallaroo Mine c.1915.

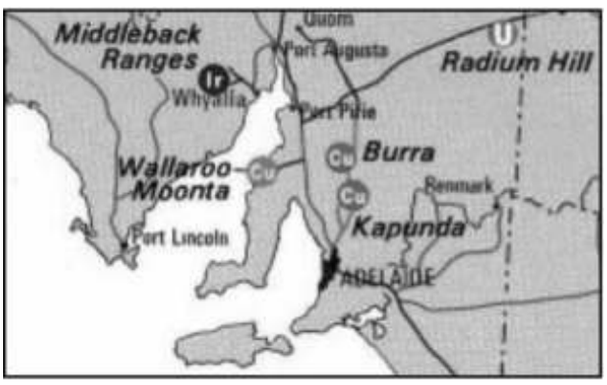
Overhand stoping at Wallaroo Mines, c.1915.

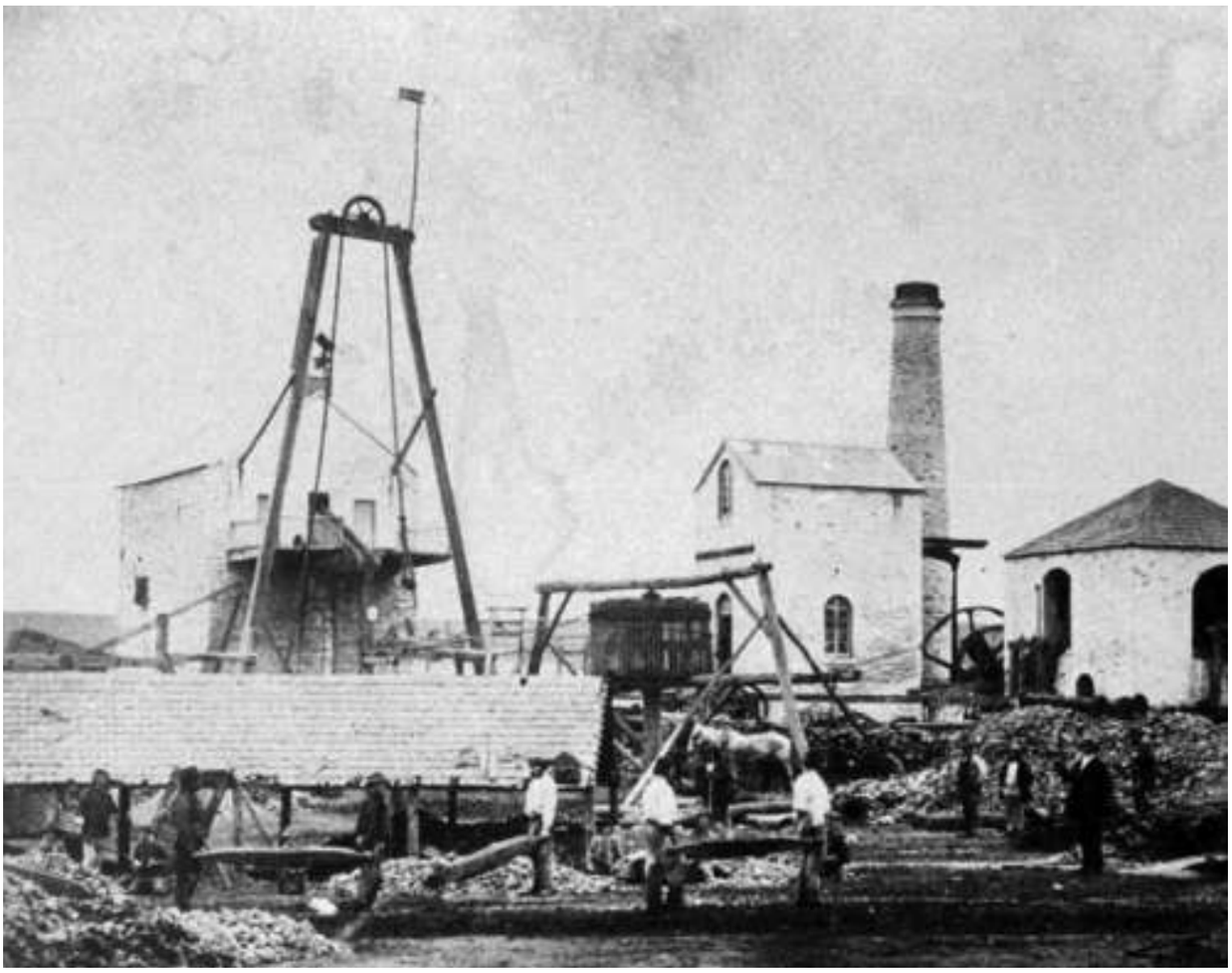
The mines were worked by forms of contract employment called *Tribute* and *Tutwork*. *Tutwork* involved the development of the mine (dead work) by sinking of shafts and driving of levels. *Tribute* was used for extraction of ore and each party of miners or pare was paid a proportion of the value of ore.

The underground workings were surveyed into blocks or pitches. Each pitch and tutwork contract or take was numbered and let by public auction on Survey or Setting Day for a period of two months. Each pare was responsible for breaking and sorting ore, tramming to a shaft, and paying for hauling and ore dressing of ore, candles, tools and gunpowder.

Each contact or take lasted for two months after which another contract was let. The day when miners were paid for the previous take and took new contacts was known as Survey or Setting day. This was a traditional holiday. The pares bid against each other for the various tribute pitches and *tutwork* contracts, the lowest bid being successful.

The bids were given as a value per £. e.g. 1/6 tribute would mean the pare would be paid 1/6 for each £ of the total value of their ore. The tribute was controlled by the richness of the ore contained therein. If it were rich perhaps 4/- or 5/- tribute would pay the men fair wages, whereas if it were poor 10/- or more might be required.





Bremer Mine, c.1865.

At the next renewal of the pitch, the tribute rate was readjusted until the lode failed. A subsist was advanced to pares until the next survey day.

Ore from shafts was hand-picked at the surface into high grade (prills), low grade (drage or halvans) or waste (attle). Prills were reduced to walnut size and sent for smelting. Drage was reduced to sand size and sent to ore floors for concentration or dressing by jigging and buddling.

Up to the introduction of mechanised dressing machinery after 1860, ore dressing was very labour intensive employing large numbers of men and boys. Women or bal maidens were also employed in dressing ore but this tradition was not implemented at Burra or Moonta

During a take, each pare's concentrated ore was placed in a separate pile. These piles were flat topped and up to 0.75 metres high and 4 metres square. At the end of a take each pile had to be sampled to determine the amount of copper as the miners were paid on that basis.

To ensure a representative sample, the tributors ensured that the pile was thoroughly mixed by re-turning and cutting. The company sampler then bagged a small sample for assay. A set of portable scales was then used to weigh the pile a hundredweight at a time.

A weighed amount of each sample was dried and re-weighed to determine the water content. This ore sample was taken to the mine Assay Office where the copper content was determined by fire assay. This assay value and the net weight of the tributors' pile allowed the total amount of copper and hence its value to be calculated.

The assay value was critical as it determined the pare's payment. Many disputes arose concerning the value so an independent value was obtained for comparison. Dissatisfaction with the company's assays led to a four month strike at Burra in 1848.

Garden Island Tunnel system

There is a tunnel system under Garden Island that was once used by the Royal Australian Navy. Within this tunnel system was a power station, offices and air raid shelters. This tunnel complex also had a command centre. Other tunnels also exist which headed further in towards Kings Cross.

The tunnels were used to move guns from one side of the island to the other. There are also older tunnels that were used to transport ammunition. During a refurbishment in 1978, most of the tunnels were reinforced with concrete and steel. They are now only used to run communication and fuel lines across the island.

The island also has a pit that was built in the 1800s and was used as a storage facility in case the island was ever attacked. The entrance to this pit has now been sealed.

Two separate tunnel systems were blasted out of the sandstone under Garden Island during World War II. They were to serve as air-raid shelters in case the Royal Australian Navy base was attacked. One system was built at the base's northern end, with another dug into the slope running down from Potts Point.

Under and around the Captain Cook Graving Dock there remain tunnels associated with the dock itself.

Adelaide hotel tunnel mystery

Not many hotels offer guests the chance to wander through an underground tunnel system, but a place in Adelaide does.

The Medina Grand Adelaide Treasury celebrates its 10th birthday this year, but the building's foundation stone was laid more than 170 years ago. The original structure was demolished in the 1850s and rebuilt as part of a complex of government offices, although one section of wall from the original 1839 building remains standing.

The restoration work required to create a 4.5 star apartment hotel cost more than $20 million. The result is 80 beautifully appointed studio rooms and open-plan apartments, as well as the Treasury on King William restaurant and bar, indoor swimming pool, sauna and fitness centre. But what makes the Medina Grand Adelaide Treasury so special is its heritage features, including wooden staircases, vaulted brick ceilings, limestone walls and cast-iron columns. There are also artefacts on display that were discovered during the restoration work, including old coins, glassware and cutlery, as well as many old photographs hanging on walls throughout the property.

The building has seen more than its fair share of historically significant moments. For almost a century, members of various Premiers' inner-circles made important decisions in the Cabinet Room. Australia's first gold coin, the Adelaide Pound, was minted on the premises. The courtyard provided shelter for settlers queuing for land grants in the 1840s, while The Beatles evaded fans by running through it in 1964.

The most mysterious and mythologised section of the building is its network of underground tunnels. Much of the mineral wealth extracted from the Victorian goldfields in the 1850s was stored there.

It was once thought that the smelting of gold was carried out in two small furnaces that remain in the tunnels. In reality, a ground-floor furnace room took care of the gold, while the underground kilns provided warmth for State cartographers and surveyors creating maps in their subterranean offices. The famous explorer Charles Sturt worked there for a time, as did Robert Torrens, the third Premier of South Australia and the man behind the Torrens title system of land ownership still used in many parts of the world to this day.

Mystery still surrounds the entrance to a sealed tunnel at the northern end of the treasury vaults. It is thought that it once provided access to the nearby Torrens Building, giving rise to talk of secret underground railway lines and emergency escape routes. Its most probable use was for the movement of government paperwork and officials between the buildings.

The National Trust of South Australia runs weekend tours of the tunnels and other historically significant areas of the Medina Grand Adelaide Treasury. However, one of the joys of staying at the hotel is that you can wander through the tunnel system whenever you please. Another benefit is its close proximity to many of the city's major attractions, such as the Botanic Gardens and Central Market, as well as the shops and eateries of Rundle Mall.

Chemical weapons and railway tunnels

Abandoned railways have been used for a number of purposes, but none stranger than for the storage of chemical weapons. During World War II, the tunnels of the old Great Western Railway in the Blue Mountains were used for this very purpose. In a top-secret operation, the Royal Australian Air Force (RAAF) imported mustard gas and the lethal choking agent phosgene. Around one million chemical weapons were imported from 1942 to the end of the war, and many of them passed through the Blue Mountain tunnels.

As the Japanese swept south towards Australia, intelligence revealed they possessed a well developed, chemical warfare organisational structure as well as ample chemical weapons and defensive equipment. Indeed, samples of their chemical weapons were captured in Papua New Guinea and brought back to Australia for analysis.

Although the initial use of chemical weapons was prohibited, the law did not prevent a nation either manufacturing or importing such weapons, thus reserving a capability for retaliatory strikes. It was on this basis that the Australian authorities covertly imported its 'insurance' stocks.

The question 'Where do we store them?' was asked. Wing Commander Le Fevre, Chemical Adviser to the Officer Commanding the Far Eastern Command, Royal Air Force (RAF), provided the necessary advice. He had arrived from Singapore early in 1942 to oversee the organisation of the RAAF's Chemical Warfare Section and was the right man for the job, as he had selected sites and supervised the storage of British chemical weapons in Malaya. During this search for suitable storage sites, he chanced a meeting with the curator of the Raffles Museum, whose archaeological and speleological interest had equipped him with a thorough knowledge of excavations and caves throughout the Malayan Peninsula. On the curator's advice, Le Fevre examined the Batu caves just outside Kuala Lumpur. Those that were suitable were cleared of bat dung and used by the RAF to store chemical weapons.

250 lb bombs at the Marrangaroo tunnel entrance.

Although caves were not available around Sydney some bright spark remarked, Four rail tunnels in Australia were chosen by the RAAF as chemical weapons storage facilities. Marrangaroo (Lithgow) and Glenbrook tunnels were first used, followed by Picton and later Clarence. Clarence, Glenbrook and Marrangaroo tunnels were part of the Great Western Railway.

Clarence tunnel formed one of the zigzag sections of the railway and had been built between 1866 and 1869. The Zig Zag Railway was constructed to enable produce to be taken to Sydney from the prosperous farming areas beyond the Blue Mountains and to develop the coal and iron ore deposits found in the Lithgow Valley. The line to Lithgow was completed in June 1874, but by the end of the nineteenth century, rail traffic over the Blue Mountains had increased sufficiently that the single track proved a bottleneck. This was relieved by the construction of a 10-tunnel deviation through the escarpment, completed in 1910. The original alignment with its three tunnels fell into disuse soon after. The tunnel at Picton formed part of the original main southern line that had also been bypassed by a new line. All the chosen tunnels were thus abandoned and available for storage during World War II.

The Glenbrook tunnel was originally leased from the New South Wales Railways by Herbert Edward Rowe (known affectionately as 'Pop'), an out-of work master builder, in 1933. Mr and Mrs Rowe had the idea of growing mushrooms in the disused tunnel, and took up residence in an old Wirth's Circus tent that they pitched on a flat area to the right of the entrance to the cutting leading into the top end of the tunnel. A small cave formed by some overhanging rock was the Rowes' kitchen, and a culvert under the Great Western Highway was their 'cold chest'. A pool dug at the end of the culvert was their water tank, and Bert Rowe built his own mushroom-growing beds. In the early stages of the mushroom-growing project, the spore was obtained in blocks about 12 feet by 6 feet from a Mr Hearn of Como, near Sutherland.

On 6 January 1942 the Air Board approved the RAAF's acquisition of the disused 660 metre long railway tunnel at Glenbrook for the storage of bombs, a move that occurred on 4 April 1942. A variety of ammunition types, including chemical ammunition, was stored at this site over the years. The chemical weapons consisted mainly of bulk drums of mustard gas (50/90 gallon and Chemical Special No. 6), but also included 65 lb bombs (empty). On 9 August 1942 arrangements for the first intake of chemical weapons at Glenbrook were completed with material received from the ship Nigerstrrom. On 14 July

1943 the Director of Armament staff (RAAF) conducted inspections of chemical weapons storage and maintenance facilities at Glenbrook. The following was noted:

'Drums stored at both ends of the tunnel in the open due to insufficient tunnel space must be maintained at once as they are rusting badly' and 'the maintenance of drums steel charged H [mustard gas] was proceeding slowly, but was of a high standard'. The weapons were regularly 'vented'; as the containers built up a pressure they needed to be regularly dragged out of the tunnel and the bung taken out to relieve the pressure, before being repainted and replaced. A boring, but very necessary, chore. Chemical warfare armourer Mel Carney recalls the delicate work of backing a semi-trailer into the tunnel.

…at the time we were going to get rid of the gas [1946], they were all taken first, so they could back the semi-trailers down the tunnel or run them down frontwards and back them out. So you just had room to get in with the trucks. They had to try and work from both sides if they could, which was difficult. In a straight it was alright, you could run the semi; once you got to the curves, you had to get rid of the drums from both sides of the tunnel. I never realised that semi-trailer drivers were so good at their job. You know, standing on the running board, reversing up a tunnel...using his controls, his hand throttle from the running board. I guess we had to take our hats off to those chaps...because really, to us, they were just drivers before that.

The RAAF inspected the disused Marrangaroo tunnel on 30 April 1942 and Air Board approval was sought for its acquisition for storage purposes. On 6 May 1942 the head of the RAAF chemical warfare arm also made an inspection, and on 29 June 1942 contractors commenced work. The tunnel and outside cutting held the chemical weapons that were in bomb form, mainly 250 and 300 pound bombs. As phosgene is odourless and lethal, it was stored in open-sided sheds in the rail cutting and the mustard gas was placed in the tunnel. On 23 August 1942 a special train loaded with chemical weapons, accompanied by guards and decontamination personnel, arrived at Marrangaroo, having been also been unloaded from the Nigerstrrom at Williamstown, Victoria.

Ray Minahan, another chemical warfare armourer, recalls the tunnel set up:

Well, the actual tunnel itself, how it was set up was the bombs were sort of stacked to the side, because it's fairly wide, and they had the little trucks like they have at the airport for towing—little things that we all learned to drive on. They were just like a minI truck and that hooked the trolleys on you know, and we would go in, pick up the bombs— they were just stacked to the side. And on the road in, they had some of the bombs stacked to the side there under sort of makeshift sheds, I suppose you'd say. Before you went into the tunnel there was an area set up with a shed there and a canopy to sort of work under in the heat ... you know, through the summer ... or a bit of shelter from the rain. And in the shed was stored whatever you sort of needed ... you know, a bit of protective gear, not that anybody wore it much. At the back of the tunnel they had guard dogs. And they also had them at the front of the tunnel and running along the side of the road—but the sheds, as I recall, were closed. I never handled any phosgene bombs there; they were already there.

Chemical Special No. 6 mustard recharging drums inside the Glenbrook tunnel.

On 7 July 1942 the Air Board approved the acquisition of the disused railway tunnel at Picton, for the storage of conventional bombs. On 4 December 1942 the Air Board approved the 'suitability' of the Picton tunnel for the storage of chemical-warfare munitions. Storage facilities at the tunnel were then constructed, with the weapons arriving in early 1943. These consisted of 250 and 500 pound mustard gas spray tanks.

Clarence was the last of the tunnels acquired, and was located in the area above Lithgow in the vicinity of the current tourist Zig Zag Railway. Work preparatory for the storage of chemical warfare stocks in the Clarence tunnel began on 28 January 1944 and the transfer of chemical warfare stocks from Glenbrook tunnel to Clarence began on 7 February 1944. The tunnel was used as a staging depot for a newly established chemical weapons storage depot in Queensland. On 15 February 1944 personnel from the new depot took charge at Clarence tunnel, and the transfer of chemical warfare stocks to the north commenced.

Immediately after the war the chemical weapons were taken out of the tunnels and either dumped in the sea or burnt in a huge conflagration at Newnes State Forest, close to Clarence tunnel. Glenbrook tunnel has reverted

to its pre-war use and is again used for mushroom farming, while Clarence tunnel forms part of the Zig Zag Railway. Marrangaroo tunnel remains abandoned, while Picton is used for ghost tours, although, according to the chemical warfare staff, the ghosts are recent additions as they swear there were none there in the 1940s.

Chemical Warfare in Australia by Geoff Plunkett looks at Australia's involvement in chemical warfare during the period 1914–1945 and can be purchased direct from Australian Military History Publications, phone (02) 9542 6771 or www.warbooks.com.au ($45 delivered anywhere in Australia). The author's website is www.mustardgas.org

Robbins celebrates 60 tears of World-Class Tunnelling

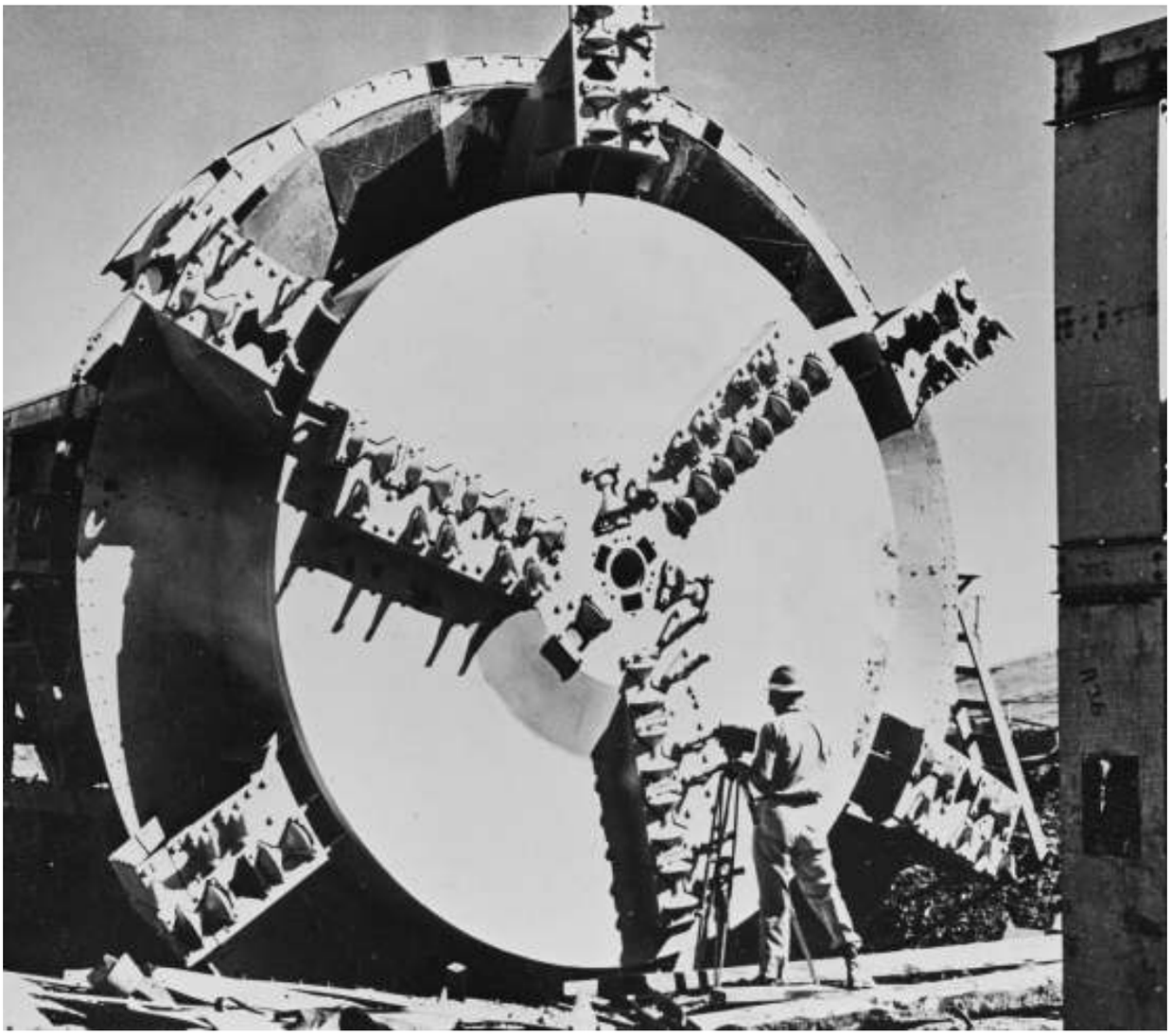
ADVANCING THE TBM INDUSTRY SINCE 1952

In 1952, James S Robbins was working in the mining industry when he came up with a plan to make excavations more efficient. That product, the modern tunnel boring machine, revolutionised tunnelling, and 60 years later The Robbins Company is still going strong.

The earliest Robbins TBMs successfully utilised picks and discs to excavate relatively soft shale at South Dakota's Oahe Dam project. Four years later, Robbins began mounting his TBMs with solely disc cutters to excavate harder ground. Canada's Humber River Sewer Tunnel was the first tunnel bored using discs alone, a design that today is used for all hard rock TBMs. "A lot of people had tried boring rock up until this time, but no machines had worked. No one could solve that problem—until Dad did," said Dick Robbins of his father James.

Upon the unexpected passing of his father, Dick Robbins would go on to serve as Robbins' president from 1958 until 1994, designing along the way the precursor to all Earth Pressure Balance and Slurry TBMs at the Paris RER Metro in 1964, and the first Double Shield TBM in 1972. That first Double Shield machine successfully excavated broken ground while simultaneously lining the tunnel with segments to maintain a fast advance rate. Other notable inventions included custom-built machines for mining applications, such as the non-circular Mobile Miner, and raise boring machines.

Today, The Robbins Company is an international developer and manufacturer of a wide range of tunnelling products, from small trenchless boring machines to mega-sized TBMs to continuous conveyors for mining



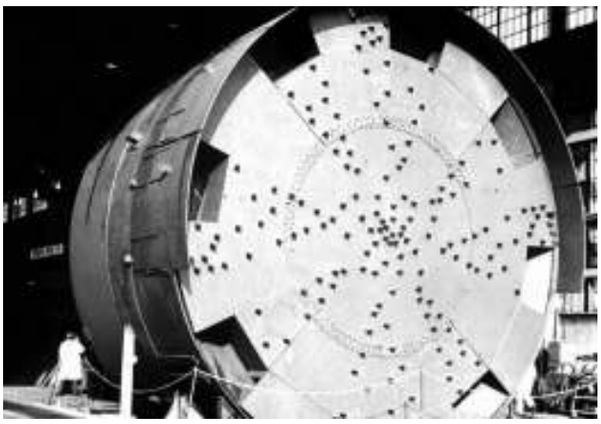
In 1952, James S Robbins developed the first modern tunnel boring machine for the Oahe Dam Project in South Dakota, USA.

James S Robbins stands in front of an early TBM excavation face showing kerf cutting.

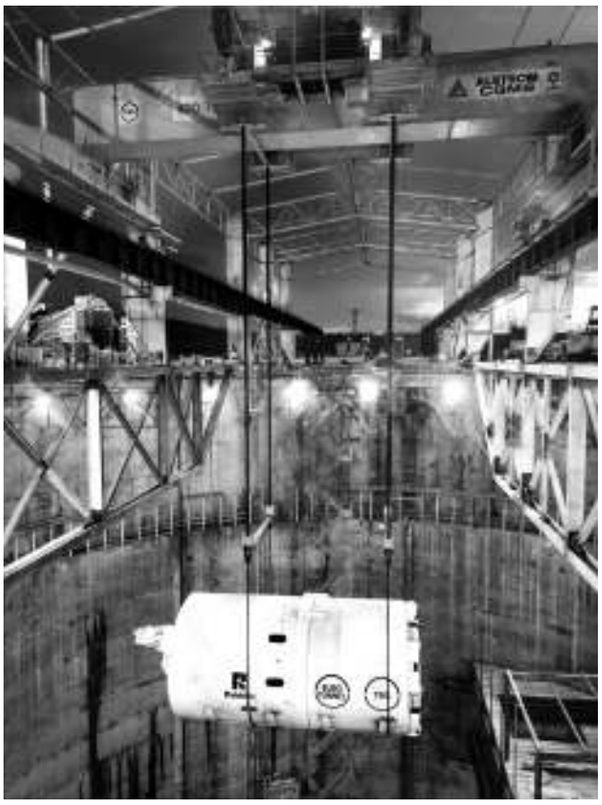
applications. "When I started at Robbins in 1968, there were 27 people and we considered ourselves TBM suppliers—nothing but the TBM. Today, we consider ourselves tunnel systems suppliers. We make everything from the cutters at the face to the stacker conveyors at the back," said Robbins' current president Lok Home.

Robbins is continuing its tradition of innovation with a range of new developments, from EPB-specific disc cutters for mixed ground, to specialised ground support, to a new method of TBM assembly. The Onsite First Time Assembly (OFTA) method was first developed at the Niagara Tunnel Project in 2006, where it enabled the swift assembly of the world's largest hard rock TBM (14.4 metres / 47.2 feet). OFTA has since been used on projects around the world, offering time and cost savings through initial assembly of the TBM at the jobsite, rather than in a manufacturing facility.

In June 2012, Robbins celebrated its landmark 60th anniversary with an event following the North American Tunneling (NAT) Conference in Indianapolis, Indiana, USA. Both Lok Home and Dick Robbins spoke at the well-attended gala, which included a historical display of Robbins artefacts and memorabilia through the years. For more information on Robbins' storied past and bright future, visit www.TheRobbinsCompany.com.



In 1964, The Robbins Company developed the precursor to all modern EPB and Slurry TBMs for the Paris RER Metro.



The epic Channel Tunnel excavation utilised multiple Robbins EPB and Double Shield TBMs to bore below the English Channel.

Robbins developed its highly successful Onsite First Time Assembly (OFTA) method for the Niagara Tunnel Project in 2006.

ATS Queensland Group Report

As the Legacy Way TBMs are blazing their way through the Brisbane geology at record production rates, the first cross passages have been excavated between both tubes.

The GLNG tunnel crossing works in Gladstone have started with the first segments cast and the launch shaft is well under construction. The tender for the Arrow tunnel is expected to occur in Q2 of 2013.

On the Bulimba creek pipe jacking project, all tunnelling is complete and the permanent works are now well on the way to completion. The Final commissioning is due to commence early February.

The Woolloongabba Sewer Upgrade Project Part B, Queensland Urban Utility's largest capital project in Brisbane to date, recently commenced, which comprises 6 pipelines, totalling 5 kilometres in length and ranging in internal pipe diameter from DN250 to DN1350 millimetres, with approximately 50 associated construction shafts ranging in depth from 4 to 18 metres. Shaft sinking and tunnel is underway ahead of schedule.

In December, among the recent effervescence of tunnelling in the mining industry, Anglo-American confirmed the order of an 8 metre EPB TBM for a decline of their Grosvenor coal mine.

Technical Activities

Since September 2012, we have held the following technical sessions:

Date	Title	Attendance
September 2012	Managing the O&M at CLEM7	60
October 2012	Underground innovation — Redpath's 50 years and beyond	55
November 2012	Groundwater issues related to tunnelling	60

The following technical sessions are scheduled for 2013, and the calendar is filling up nicely.

Date	Title
February 2013	The Waterview Connection Project — Auckland
March 2013	Designing & Constructing Legacy Way Tunnels , Brisbane
April 2013	Vehicle Access and Pedestrian Safety Project (VAPS) — Sydney Opera House

Other Activities

On 12 October 2012 the 3d ATS QLD charity golf event was held in St Lucia. . For the second time, the event was "full house" with 80 participants sharing the green on the sunny, but windy afternoon. The event raised a total of $12,120 for the Royal Brisbane and Women's Hospital Foundation.

After this year's success, the ATS Brisbane committee is delighted to announce that the 4th annual Brisbane ATS Industry Golf Day will take place on the 11 October 2013.

Informa's 11th Australian Tunnelling Conference was held on 4-5 December 2012, which was supported by the Australasian Tunnelling Society.

The committee is planning several sessions at QLD universities to generate interest and support future young tunnellers.

The QLD committee would like to announce that Christophe Bragard has resigned from the position ATS QLD Chapter Co-Chair, as he is leaving Australia to start a new chapter in his career. He is returning to his tunnel construction roots to work with a major contractor in Paris. Christophe led the QLD Chapter for the last year and we will be sad to see him go. We wish him and his family all the best for the future. Paul Barraclough will take on the responsibilities of QLD Chairman. Paul is a tunnel engineer and Parsons Brinckerhoff's Queensland Tunnels and Geotechnical Manager, based in Brisbane.

Christophe Bragard & Paul Barraclough
Co-Chairs, Queensland Chapter

Join the ATS Forum

New on the ATS website is a forum to allow members to discuss issues of importance or to seek advice from experts within the industry.

It's free to join – just register on the page

http://www.ats.org.au/index.php/forum/welcome-mat/2-welcome-to-the-new-ats-forum

ATS WA Chapter Report

Last year the WA Chapter held 4 technical sessions:

- 18 June 2012 — Jurong Cavern Project, Singapore (Matthew Ross, BASF)
- 10 July 2012 — Tunnels To And Under Airports (Ted Nye, Mott McDonald), joint session with AGS
- 1 November 2012 — History and State of the Art of NATM Tunnelling Method (Prof J Golser, Chairman of Geoconsult, Austria)
- 21 November 2012 — Tour of Leighton Battery World War II Heritage Artillery Tunnels, conducted by Royal Australian Artillery Historical Society Representative.

Two sessions involved international speakers.

Current Tunnel projects in WA include:

The Public Transport Authority of Western Australia Perth City Link Rail Project involves lowering the Fremantle rail lines into a 600 metre long cut and cover tunnel 1.3 metres above the existing Joondalup line bored tunnels, eventually to be followed by lowering of the Wellington Street Bus Station underground to enable redevelopment of Perth Rail Yard. Rail tunnel work commenced in March 2011 by the Perth City Link Rail Alliance (John Holland-GHD-PTA). Completion is scheduled for mid 2014.

A $60 million contract for a 2.0 metre diameter TBM pipe jack tunnel approximately1.2 kilometres long with water depth at the recovery site of around 20 metres was awarded to Theiss Tunnelling in December 2011 for the Wheatstone LNG project. Construction is due to start in May 2013 with completion by November 2013.

The WA Chapter Committee comprises 7 members (Craig Adamson, Mike Bluck, Richard Douglas, Gary Goodall, Eric Hudson-Smith, Ron Morley and Barry Moore) and meets monthly. The Chapter has over 70 individual members plus 6 company memberships registered in WA.

Eric Hudson-Smith
WA Group Chair

ATS Victorian Group Report

2012 was a very busy year for the Victorian Group, hosting nine successful technical sessions and organising the ATS Tunnelling Short Course in September.

The technical session activity since last report comprised a design overview of the mined tunnels and caverns on the Airport Link project by Andreas Amon. With this project now open and operating, the physical extent and complexity is becoming appreciated by a wider audience. There will many more presentations on this project as there is so much to learn and share.

This was followed in September by another enjoyable and challenging presentation by Arnold Dix. This session was incorporated as part of the Tunnelling Short Course.

The October session was an extremely detailed and comprehensive presentation on the Beauty World station and running tunnels in Singapore as part of the Downtown Line Project. This was very well presented by Paul Thomas, Project Manager for MacDow.

Unfortunately and totally out of our control, the planned final session for the year on Rio Tinto's "mines of the future" had to be cancelled. We will incorporate this topic into the New Year's program.

A successful Tunnelling Short Course took place in Melbourne over three days in September. A total of 145 delegates attended and the post course survey received endorsement and positive comments from the majority of respondents. A course wrap up document has been prepared for the Executive Committee and includes recommendations for future courses.

The Victorian AGM was held in October 2012 and despite the intensive workload of 2012 with the Short Course, all existing members have put up their hands for another year. With two new elected members, the new committee/ office bearers for 2013 are as follows; Bill Bamford, Andrew Banks, Tony Bennett (Treasurer), Chris Boyd, Richard Buckingham, Malcolm Dixon, Bruce Grant (Treasurer), David Grist, Andrew Kindred, John Main, Rob Muley and Ed Taylor (Chair).

Planning for 2013 technical sessions is well underway with the first third of the year targeting the following topics;

- Sydney Opera House Project
- Rio Tinto's Mines of the Future
- Drill and Blast innovation, Hong Kong
- Perth City Link Project

As in past years, we will be targeting for 10 technical sessions for the year. As soon as Engineers Australia confirms our bookings, the dates will be posted on the website.

Ed Taylor
Chair, Victorian Group

ATS Sydney Group Report

It has again been a relatively quiet year on the tunnelling front in Sydney with no major projects under construction save for the following smaller but still challenging projects, the Opera House VAPS project, CBD cable tunnels, the widening of the Hills M2 Norfolk Tunnel, the Wynyard Walk pedestrian link (awarded) and the North Strathfield Rail Underpass (designer appointed, contractor/builder award imminent. EOI short listed tenderers are working on their North West Rail Link submissions due early in 2013 for the civil station and tunnel works.

ATS Sydney Group has had a representative attend the Austroad Tunnel Guidelines committee meetings this year as was previously done in 2011. A site visit was made to the East Link and City Link road tunnel controls rooms associated with the Melbourne meeting.

The Sydney Group via a specially convened committee is responsible for organising the Australian Tunnelling Congress to be held in September, 2014. AusIMM will be appointed to help organise the conference which is to be held at the Hilton Hotel.

Craig Burrell has been one of three ATS representatives commenting on the Safe Work Australia document "Draft Guide for Tunnelling Work". Public comments closed in August 2012.

Peter Watson assisted by John Brown has been organising a charity golf day for the 14 March 2013 . The venue is Ryde Parramatta Golf Club and the Charity being supported is the Gavin Medical Research Institute. We are using Brisbane ATS golf day as a model to develop this event.

Technical sessions:

- 17 October 2012 — Vehicle Access and Pedestrian Safety Project (VAPS) — Sydney Opera House by Mark Adams and Nik Sikol
- 21 November 2012 — Widening the Hills M2 Norfolk Tunnel by Garret O'Connor and Andrew Marsonet

The first technical session for 2013 held on 20th February was a presentation on the design and construction of Beauty World station and tunnels in Singapore by Paul Thomas of McConnell Dowell.

Attendance has been strong with between 40 to 60 people at these sessions.

Australasian Tunnelling Convention — September 2014 at Hilton Hotel, Sydney.

ATS SYDNEY CHAPTER GOLF DAY 2013

The Australian Tunnelling Society's Sydney Chapter is holding a charity golf day to raise funds for The Garvan Institute of Medical Research.

Date: Thursday, 14 March 2013

Time: 12 noon for 1pm shotgun start

Venue: Ryde Parramatta Golf Club, 1156 Victoria Road, West Ryde

Format: Four Ball Ambrose 18 Holes

For more details on the golf day, please visit the registration links below.

Individual Registration:
http://www.engineersaustralia.org.au/ATSGolfDay2013

Sponsors online registration:
www.engineersaustralia.org.au/ATSGolfDay2013Sponsorship

ATS New Zealand Group Report

The NZ committee has remained the same.

The committee has been providing input to the Pike River Enquiry and has received an early copy of Royal Commission report.

Rory Bishop is providing input to the Department of Labour regarding revised regulations. A meeting was held on 5 December 2012, with a presentation on the Epping-Chatswood Link given by Doug Maconochie. There were around 50 attendees and the presentation was well received by audience with good social networking before and after talk.

Committee meetings are held on 1st Wednesday of each month over a light breakfast.

Evan Giles
Chair, NZ Group

Allen Neyland Award 2014

Nominations are now open for the next Allen Neyland Award

The Allen Neyland Tunnelling Achievement Award is an award made by the Australasian Tunnelling Society to a member of the tunnelling industry for outstanding achievement associated with tunnelling and underground construction in Australia or New Zealand. This award is made at the ATS conference, normally held on a triennial basis. The 15th Australian Tunnelling Conference will be held in Sydney in September 2014.

The Award shall be made by a decision of the ATS Executive Committee. Non-membership of the Association does not preclude nomination.

The trophy shall consist of a metal enamel plaque, symbolic of the achievements of Allen Neyland, mounted on a core of Victorian Harcourt granite. The name of the recipient shall be attached to the trophy on a metal plaque.Please submit your nominations to any members of the ATS Executive Committee.

The Award

The Allen Neyland Tunnelling Achievement Award was originally conceived to recognise outstanding contribution to the Australian tunnelling and underground construction industry on a triennial basis. From the work of Allen and others who carried the committee work of the Australian Underground Construction and Tunnelling Association (AUCTA) in its formative years, the Association decided it was appropriate to recognise the outstanding achievement of individuals by an award known as the "Tunnelling Achievement Award", with the presentation at the triennial AUCTA Conference. After a succession of four (4) awardees over a nine (9) year time span from 1981, it was unanimously agreed by the committee of the day that the 1993 award would be made posthumously to Allen Neyland following his untimely death, and henceforth the award would be known as the "Allen Neyland Tunnelling Achievement Award" in recognition of his service to AUCTA and the tunnelling and underground construction industry.

Allen Neyland

Allen's contribution to tunnelling ranged from his early service in the Snowy Mountains Scheme following graduation from the University of Melbourne in civil engineering. A subsequent career move took him to the H.E.C. at Poatina in Tasmania and the introduction of the first Robbins TBM to Australia.

He subsequently moved to the Melbourne and Metropolitan Board of Works on Section 3 of the South Eastern Trunk Sewer project, and was associated with the pioneering development of the well known "Melbourne Head" of the Robbins Company to overcome stability problems in broken ground.

- The latter part of his career was with Jacobs Associates and the Connell consortium principally on the Melbourne Underground Rail Loop project, ultimately as Chief Construction Engineer, and advisor on other significant infrastructure projects such as:
- Sydney Harbour Tunnel
- Brisbane Inner City Rail Tunnels
- Melbourne Water North Western Sewer
- Melbourne Water Western Trunk Sewer
- Sydney Ocean Outfall Tunnels.

PREVIOUS WINNERS

Tunnelling Achievement Award

1981 — Alan Croxford — MMBW
1984 — Stan White — Allied Construction
1987 — Frank Watson — Melbourne Water
1993 — Allen Neyland — Jacobs Associates

Allen Neyland Tunnelling Achievement Award

1996 — David Sugden — D B Sugden & Associates
1999 — Robert Cooper — Tenix
1999 — David Baxter — Baxter Tunnelling
2002 — Mike Wille — Transfield Tunnelling
2005 — Alan Chappel — Connel Wagner
2008 — Philip Pells — Pells Sullivan Meynink
2011 — Arnold Dix

LETTER TO THE EDITOR

Dear Sir

Bolts Belittled

Bans on use of so-called permanent bolts on parts of two Brisbane tunnel projects in recent years and replacement with cast or sprayed concrete has caused some angst and reputedly caused greatly increased costs. Why was this done? To this writer there can only be two reasons, either there was little faith per se in the durability of bolts or there was no faith in the ability or willingness of contractors to carry out the testing regimes recommended by current codes and practices.

It could be beneficial to go back to where we have come from (a popular past-time at the moment) with bolting in the last couple of decades. A significant project in the early 1990's was the Sydney Opera House car park (SOH) which introduced design from the coal mining industry based on beam building in flat-bedded strata. This was later picked up for design of the Eastern Distributor, M5 east and Cross City tunnels. SOH was reinforced with epoxy coated Macalloy bars and galvanized bars all cement grouted. These days they would almost certainly be sheathed. If corrosion occurs it is possible to replace the bolts from below or above.

Other tunnels about this time or a little later, such as the Brisbane Inner City Rail tunnels, adopted the conventional approach of temporary bolts followed by an in-situ concrete lining.

As 1995/1996 approached more interest was being shown in relying on bolts and shotcrete as the permanent linings. The M2 tunnel in Sydney would rely on permanent bolts with mechanical galvanized anchors. Grouting was delayed to allow any movement which might deform the bolt holes to occur first. The current upgrade should provide a unique opportunity to check the state of bolt corrosion, if any, although it appears no attempt has been made yet. Such information might throw light on how other tunnels with unsheathed bolts are fairing.

The Molyneux Project ("the Sydney Gas Chambers — the final solution" was the name given to the project at an Australasian Tunnelling Society meeting address by an Elgas executive, oh dear!) was an interesting one. The French designers when asked about the durability of the proposed steel bolts gave a Gallic shrug and with a nod to Shakespeare said: "durability has never entered our philosophy but we will have seismic monitoring". From that it can be assumed that if the roof fell in they would at least know when. They left it up to the contractor to find the cheapest combination of bolt/hole/grout possible.

In 1996 Nick Barton reported on the newly developed sheathed C-T bolt at the Australian Tunnel Conference. At the same conference, my paper with the whimsical title " Do all rock bolts rust" was published. The title was a quote from Stillborg's book — 'Rock Bolting'. Apart from discussing all the corrosion mechanisms, it attempted to show that long term bolts had to be sheathed and tested comprehensively. Because the bolts are subsequently buried, more attention to quality control than the current 'quality assurance paper exercise' and contractor self certification was recommended.

The New Southern Rail (Airport Link) was under way by this time. The documentation allowed for a dowel consisting of a steel bar inside a fibreglass sheath for use in the vertical walls — it was far too expensive and was replaced with fibreglass bolts. Shotcrete was specified as an alternative for use as a permanent lining — it proved more expensive than in-situ concrete for the roof arch, but was used for the walls.

The Eastern Distributor in Sydney was getting under way 1996/97 and adopted the same approach as the SOH car park. Epoxy coated steel was intended for the lighter loaded bolts and sheathed strand bolts for the rest. Coated bolts are vulnerable to damage during handling with the danger of accelerated corrosion. The design life for the bolts was only 50 years but that for the shotcrete was 100!

The Melbourne City Link tunnel was underway in 1997 using the conventional temporary bolting followed by an in-situ concrete lining. The M5 east in Sydney came along and used the same sort of analysis as the Eastern Distributor. The bolts were C-tube bolts. Later the Epping-Chatswood Rail Link used sheathed bolts fairly extensively followed by Lane Cove. Cross City tunnel in Sydney followed along similar lines.

It should be noted that flat roof design in Sydney's Hawkesbury Sandstone won't be possible if there are no acceptable durable bolts. Neither will one pass tunneling be possible in any strata.

The recent Eastlink tunnel in Melbourne had permanent/durable sheathed bolt designs but in the end were only used in a rock batter.

Getting back to the question, I don't believe that properly installed sheathed bolts cannot be durable. There are rock anchors unsheathed in a dam in Algeria which must be getting on for 80 years in age now — source: Stuart Littlejohn (of BS 8081 fame)as referenced in my 1996 "bolt" paper. Therefore the only other answer is a lack of faith in self-certification.

I can only assume that the choice put to the client (Main Roads) went something like this: Would you like a solid concrete lining, which you can see, drill holes in, take samples, lick it, taste it etc or would you like a support system relying on steel bolts buried in a hole which may or may be not be completey filled with grout of good quality — in other words a pig in a poke — installed by a

contractor, who is unknown at the stage of making the choice, and when the client has to rely on so-called self-certification that the rigorous installation procedures and testing required in an industry where some contractors are more equal than others in applying themselves to Q.A. I would hazard a guess that Main Roads' engineers are mostly bridge engineers and I don't think they would choose anything other than a concrete lining after some of the problems of ensuring the integrity of bolts were explained.

David Baxter

The author has a more than passing acquaintance with the Melbourne Underground Rail Loop, Eastern Distributor, Sydney Harbour Tunnel, Brisbane Rail Tunnels, Molyneux Project (Elgas Storage Chambers), Homebush Rail Tunnel, New Southern Rail (Sydney's Airport Link), Epping-Chatswood Rail Link and Eastlink.

A new discussion on this issue has been started by David on the ATS Forum — log in and join the discussion and give us your opinion:

http://www.ats.org.au/index.php/forum

GHD digs its new tunnel guru

One of the world's leading engineering, architecture and environmental consulting companies, GHD, is responding to growing market needs for experienced tunnelling professionals in appointing Evan Stamatopoulos as its Major Projects Executive — Tunnels.

Evan has 30 years of experience on civil and tunnelling projects in Australia, Europe and Asia. This includes project management of multidisciplinary teams for heavy civil works, mechanically excavated tunnels (using Tunnel Boring Machines and Roadheaders), and conventionally excavated tunnels (using drill and blast methods and hand mining).

Speaking on Evan's appointment, GHD Manager — Tunnelling, Malcolm Dixon said, "We're delighted to welcome Evan to the GHD family and confident that his talent in leading teams across the globe will go a long way to offering our clients a more robust capability in this space".

John Holland — Tunnelling Contractor of the Year

On 26 November 2012 John Holland won the "Tunnelling Contractor of the Year Award" at the International Tunnelling Awards in Toronto. Several successful contracts bought in under budget made John Holland the go to global contractor of the year — this included:

- The Northern Sewerage Project
- Melbourne Main Sewer Replacement

The judges said: "John Holland has emerged as a key force in the tunnelling contracting world this year particularly through its successful delivery of challenging, high profile projects in Australia. lts work on both the Northern Sewerage Project and Main Sewer Replacement Project in Melbourne — both below budget and delivered ahead of time — has cemented its position as the go to contractor in the region. Working in joint venture it has also delivered outstanding performance on the Brisbane Airport Link and is increasingly the one to watch when it comes to complex tunnelling".

The other shortlisted contractors were Taylor Woodrow/ Bam Nuttall JV, Bouygues Civil Works Florida, Fletcher Construction, Obayashi Corporation and Thiess.

John Holland has emerged as a key force in the tunnelling contracting world this year particularly through its successful delivery of challenging, high profile projects in Australia.

New foaming agent targets sustainability

Foam and additives manufacturer Condat has launched CLB F5, a new generation of eco-friendly foaming agent formulated to avoid water pollution and expensive use of polymers.

Designed for eco-compatibility and to facilitate safe and efficient soil extraction, the new formulation is claimed to decrease the consumption of conditioning agent by 20 per cent; produce optimum and stable foam whatever the quantity of air injected (foam expansion rate (FER)); and allow the generation of a stronger foam, even at low concentrations. Its use can also result in a lower global consumables budget and a reduction in underground pollution.

Being highly degradable, CLB F5 can also facilitate soil disposal and keep pace with OECD regulations.

New Robbins Asia Pacific Office

A new Robbins office, opened in the last quarter of 2012, is providing coverage for Australia, New Guinea, New Zealand, and Indonesia. The subsidiary, Robbins Asia Pacific Pty Ltd., joins a second Asia Pacific office based in Hong Kong. "Australia is a market with a lot of potential, not only in the civil sector but also in the mining sector, particularly for coal and precious metals," said Doug Harding, Robbins Vice President-Sales.

The office is based in Brisbane and headed by General Manager Martin Rauer, who has over 13 years of experience in the tunnelling industry in both manufacturing and contracting firms. While sales is the main function of the subsidiary, field service, project management, spare parts services, and other types of support will be added as market share increases. "Customers will benefit from faster response times and more extensive local assistance and communication," said Harding.

The office will also provide regional support for two new Robbins projects in Australia, both for use in mine development tunnels. Later in 2013, an 8 metre) diameter hybrid EPB will be launched on the Grosvenor Decline Tunnel at the Anglo-American Coal Mine. The 1 kilometre tunnel, at a grade of 1:6, will require an explosion proof machine design for excavation in mixed ground with possible pockets of methane gas. In early 2014, a 5.83 metre diameter Robbins Main Beam TBM will excavate the Carrapateena Decline tunnel for the Oz Minerals copper and gold mine in southern Australia.

Within the next five years, the subsidiary aims to further mine development using TBMs, and to increase sales for both hard rock and EPB machines. Office contact information:

Robbins Asia Pacific Pty Ltd.
Brisbane, Australia
Phone: +61 (0) 447 050509
Email: rauerm@robbinstbm.com

Balfour Beatty target Australian highways contracts

Balfour Beatty, the international infrastructure group, in a 50:50 partnership with Transfield Services, has formed a bid consortium to target State government outsourcing opportunities in highways maintenance on the East Coast of Australia.

Balfour Beatty has mobilised a specialist UK team to support its professional services arm, Parsons Brinckerhoff, to establish this partnership and provide the local strategy, tactical and design capability from its Australian resources.

A New Herrenknecht Subsidiary

On 12 December 2012, Herrenknecht AG took over the French manufacturer of tunnel supply vehicles, the company Techni-Métal Systemes SAS (TMS) in Livron. By acquiring TMS, Herrenknecht is expanding its full-range portfolio which comprises all technical equipment and services around innovative tunnel boring machines.

Schwanau, Germany, 20 December 2012.Techni-Métal Systemes SAS (TMS) designs and produces tired, non rail-bound special vehicles which are used on tunnel construction sites to transport personnel, lining segments, extracted material and other rolling stock. The cooperation between Herrenknecht and TMS has existed since 2007. It has already led to cooperation in diverse projects in which TMS' special vehicles provided for optimised logistics solutions. TMS vehicles and Herrenknecht tunnel boring machines have been used, for example, in projects in the Netherlands, Malaysia and Russia. With the company takeover in December 2012, Herrenknecht is integrating TMS' specialist know how and engineering expertise into its group portfolio.

The multi-service vehicles for heavy-duty transport produced by TMS are self-propelled and equipped with double driver's cabins. They are driven by powerful diesel engines with an integrated particle filter (exhaust emission standard EPA 3 Tier3). The power is transmitted by steered drive shafts. All required welding structures are made of high-strength steel. Around 20 engineers and specialists from Techni-Métal Systemes SAS bring their expert knowledge in engineering, design and vehicle assembly with them. In addition, Herrenknecht offers its customers service and supply of spare parts for these tunnel supply vehicles. The vehicles can be used to transport personnel and material both in tunnel construction and in mining.

TMS will be managed by Philippe Fraunhofer (graduated industrial engineer FH) and Pierre-Matthieu Hieber (mechanical engineer) of Herrenknecht AG. "TMS offers state-of-the-art products, which are indispensable for modern tunnel construction, because quicker tunnelling performances must go hand in hand with very efficient transport systems in the back area", says Gebhard Lehmann, Vice Chairman of Herrenknecht AG's Board of Management. "As a full-service provider in tunnel construction we are now able to offer our customers an even broader range of additional equipment as integrated solutions."

Trenchless Live 2012 an industry success

Over 900 participants attended one of the largest trenchless exhibitions ever hosted in the Southern Hemisphere, held in Melbourne from 22-24 October 2012. Live demonstrations were the centrepiece of the conference program with exhibitors displaying the latest Trenchless Technology.

Over the course of two days, delegates attended Super Panel and Toolbox Sessions led by world class trenchless experts. Kicking off the proceedings on both mornings were the Keynote Breakfast Presentations. Neil Rickard, Yarra Valley Water Divisional Manager — Infrastructure Planning, covered asset management at the major water utility in Tuesday's session. The presentation detailed the upcoming investment opportunities for trenchless in Melbourne. The conference featured sessions on rehabilitation and standards, HDD, and tunnelling and mapping. In between these sessions was the main feature — Live Demonstrations. Attendees had the opportunity to view an impressive array of the latest technology in action.

Live demonstrations

Highlights from the demonstrations included Veolia's ear-busting vacuum excavator, Kembla Watertech's pipe relining and Vermeer's crowd pulling Axis Guided Boring machine. Those who made it to the end of day two were lucky enough to see Vermeer's guided boring machine break through the wall after drilling over 25 m underground.

Interflow demonstrated three of their best products, including an HD profiler for large diameter pipeline inspection. Other live exhibitors included Austeck, Ditch Witch, GN Solids Control, Austunnel, LKL International, TT Asia Pacific and Queensland Drilling Sales and Supplies.

Trenchless talk

Upon registering for the conference, delegates were offered the opportunity to submit questions on various techniques to shape the discussion. The Super Panel was moderated by the ASTT Chairman Trevor Gosatti, who posed delegated-submitted questions to panellists MWM's Dave Cook, Sastti JV's Lance Horlyck, QUU's Ken Vaheesan and Yarra Valley Water's Neil Rickard.

The well-attended session resulted in a lively discussion on the benefits of different techniques, offering solutions for delegates' rehabilitation and installation of underground projects.

Trenchless in 2013

No-Dig Down Under 2013 will be held from 1–4 September 2013 at the Sydney Convention and Exhibition Centre. The Australasian Society will co-host with the International Society of Trenchless Technology.

Visit the No-Dig Down Under 2013 website to find out more information.

New steel fibre could mean thinner concrete segments

"One fibre can hold 100 kilos" — that is the dramatic claim made by Belgium-based steel fibre manufacturer Bekaert at the launch in London of its new Dramix 5D-steel fibre for concrete reinforcement.

The new fibre is claimed to be the first structural fibre with bending-hardening properties, and could result in dramatically thinner tunnel lining segments, even at dosage rates of 30-35 kilograms per cubic metre of concrete.

Other benefits include a non-deformable hook said to provide perfect anchorage, and ductile wire which elongates while the hook remains firmly in place, enhancing both the strength and the ductility of the concrete.

Currently being promoted for use in horizontal elements, such as reinforcement for industrial piled floor slabs, the new fibres are also being evaluated for inclusion in tunnel lining segments.

A spokesman for Bekaert told World Tunnelling that specimen segments are ready for testing, although definite conclusions as to their impact on tunnelling are some months away.

If the tests are successful, the impact on tunnelling will be great as it could lead to larger tunnel diameters using fibre-only solutions, thinner and lighter segments, greater crack control, less rebar, a reduction in excavated material, etc. The fibre could also have beneficial impacts on sprayed concrete but this is also undergoing trials.

BASF sells MEYCO equipment business to Atlas Copco

BASF has signed a contract with Atlas Copco to sell its MEYCO Equipment business providing concrete spraying machines to the tunnelling and mining industries. The machinery manufacturer, which is based in Stockholm, Sweden, will continue operations at the only production site of MEYCO Equipment in Winterthur, Switzerland. Both parties have agreed to not disclose financial details of the transaction. The purchase is subject to approval by the relevant authorities and legal closing of the transaction is expected by the end of the first quarter of 2013.

In BASF, MEYCO Equipment is part of the Construction Chemicals division's global underground construction activities providing mainly chemical solutions for tunnelling and mining. Chemicals optimising the properties of sprayed concrete strongly contribute to the efficiency of the spraying process and the quality of its final results. However, the business of engineering, assembling and selling concrete spraying machines is driven by success factors different from the chemical industry.

"Atlas Copco offers excellent conditions for the future development of MEYCO Equipment as a machinery business," said Dr Tilman Krauch, President of BASF's Construction Chemicals division. "At the same time it is our goal to maintain the benefit of optimised solution packages consisting of machines and chemicals. Therefore, we aim to establish a close partnership with Atlas Copco in the field of product development," explained Krauch.

"The acquisition of MEYCO Equipment is a good strategic fit for Atlas Copco as it broadens the offering for our existing customers by equipment for shotcreting," said Bob Fassl, Business Area President for Atlas Copco Mining and Rock Excavation Technique. "Shotcreting is a growth segment thanks to high safety requirements in tunnelling and we look forward to introducing these products through our global sales channels, both to mining and underground civil construction customers."

New tunnel drama

A TV crime series based on the discovery of a body in the Channel Tunnel is to be made in Folkestone this year. The 10 hour long episodes of The Tunnel, the UK version of the hit Scandinavian thriller The Bridge, will be filmed on location in Shepway, Dover and Calais

The plot revolves the discovery of a body cut in half and found at the exact centre of the tunnel. Because of the position of the body, it involves detectives from both Britain and France. The detectives — a British man and a French woman — are vastly different characters and their relationship is central to the series.

The Tunnel is being made jointly by British production company Kudos, and French company Canal and has been commissioned by Sky Atlantic. The series will take about six months to make.

The original Swedish-Danish production, shown earlier last year, became a cult hit with more than one million viewers tuning in for the first episode. Other countries as well as the UK are scrambling to make their own versions of the series. In the US, the series will be called The Border and will involve American and Mexican detectives.

Sydney engineer joins international young tunnelling elite

Parsons Brinckerhoff Senior Mechanical Engineer, Sean O'Gorman, was shortlisted for 'Young Tunneller of the Year' by the NCE International Tunnelling Awards 2012.

Mr O'Gorman is one of only three tunnelling professionals in the world, and the only finalist from Australia, to be recognised in this category.

He specialises in tunnel ventilation and fire life-safety design with particular experience in the design of high-profile road and rail tunnel projects, such as:

- North West Rail Link
- M5 East Duplication
- Sydney Metro (stage 1 and 2)
- Airport Link, Northern Busway (Windsor to Kedron) and Airport Roundabout Upgrade.

At the age of 34, Mr O'Gorman has already led a technically challenging project, the M5 East Duplication — delivering it on time and under budget. On this project, he was the mechanical and electrical design manager, leading a team that developed a concept design for the road tunnel duplication.

Mr O'Gorman is also involved in developing the latest version of the World RoadAssociation (PIARC) guidelines.

The award was won by Kenneth KO Kwong Yu of Hyder Consulting from Hong Kong. The Awards took place in Canada on 29 November 2012 at the Sheraton Hotel in Toronto.

New European tunnel body aims to enhance tunnelling

A research body launched recently in Lyons, France, will aim to address the key scientific and technical challenges in tunnelling over the next few years.

A total of 21 industry, research and development laboratories, plus various small/medium enterprise partners from nine European countries, gathered on 14 September 2012 at the École Centrale de Lyon for the launch of the New Technologies for Tunnelling and Underground Works (NeTTUN) Collaborative R&D project, funded by the European Commission (EC). Initiated and managed by France-based TBM-maker NFM Technologies, NeTTUN will address key scientific and technical challenges in the tunnelling sector over a period of 4.5 years. The NeTTUN work programme of interrelating projects intends to dramatically enhance every aspect of the lifecycle of tunnelling — ranging from design and construction, to the maintenance of Europe's already very extensive tunnel legacy.

Each NeTTUN partner has been invited to participate because of its unique scientific expertise and specialist tunnelling sector experience.

Research and development goals set by NeTTUN and the EC include:

- An advanced multi-sensor ground prediction system for TBMs to enable fast, frequent and effective detection in the ground ahead of the excavation face;
- Advanced robotics for TBM maintenance to enable automation of routine but hazardous tasks;
- Cutter tools with a greatly increased lifetime;
- A novel system for modelling global risks to be used for defining best strategy, during both design and construction phases;
- A suite of systems to model and control the impact of tunnelling on surrounding structures, and
- A decision support system for tunnel maintenance

NeTTUN plans to test and evaluate these goals at on-going tunnel projects, including on the construction of Metro Line C under some of Rome's most ancient monuments, and in partnership with Spanish contractor OHL on the tunnel beneath the Guadalquivir river, as well as on future projects.

"NeTTUN will deliver maximum impact with its results, well beyond the current state of the art, to demonstrate real progress that can be utilised to the benefit of the tunnelling sector across Europe, and for European industry and R&D to compete globally," said Dr Thomas Camus, R&D manager at NFM Technologies.

NFM will manage the scientific and technical aspects of the project while École Centrale de Lyon, a leading French engineering school involved in international research, will be the NeTTUN project co-ordinator.

The NeTTUN Consortium comprises:

École Centrale de Lyon, France; BG Ingénieurs Conseils, France ; Technische Universiteit Delft, The Netherlands ; National Technical University of Athens, Greece; Deutsches Forschungszentrum Fur Kuenstliche Intelligenz, Germany; École Polytechnique Fédérale de Lausanne, Switzerland; IDS Ingegneria Dei Sistemi, Italy; Inexia, France; École Nationale Des Travaux Publics De L'État, France; NFM Technologies, France; Sial.Tec Engineering, Italy; Metro C SCPA, Italy; Obrascon Huarte Lain, Spain; Razel, France; University of Leeds, UK; Société Nationale des Chemins de Fer Français ; Tallinna Tehnikaulikool, Estonia; Universita Degli Studi Di Roma Tor Vergata, Italy ; Université de Limoges, France; Centre D'Ingénierie Des Systèmes de Télécommunication en Electromagnetisme et Electronique, France; MI-Partners BV, The Netherlands.

Further information is available from Ashleigh Ogier, NeTTUN project support officer, at NFM Technologies: ashleigh.ogier@nfm-technologies.com

CONFERENCE AND EVENTS DIARY

Tunnelling Asia 2013 — 26-28 February 2013 — New Delhi, India
http//www.cbip.org

International Symposium on Tunnelling and Underground Space Construction for Sustainable Development
18- 20 March 2013 — Seoul , Korea
http://tu-seoul2013.org

http://www.ausimm.com.au/coalchain2013/

http://hse.flemingeurope.com/tunnels-fire-safety-forum/?utm_source=EDM&utm_medium=SP&utm_campaign=HP

6th China International Underground Engineering & Tunnel Technology
28-40 April 2013 — Shanghai
http:// www/tunnel-expo.com

12th International Conference — Underground Construction Prague 2013
22-24 April 2013 — Prague, Czech Republic
http://www.ita-aites.cz/en/conference_underg_constr/conference-uc-2013/

World Tunnel Congress 2013 and 39th ITA General Assembly
May 31 – June 7 2013 — Geneva, Switzerland
http://www.wtc2013.ch/home.html

The AusIMM International Uranium Conference 2013
11–12 June 2012 — Darwin
http://www.ausimm.com.au/uranium2013/

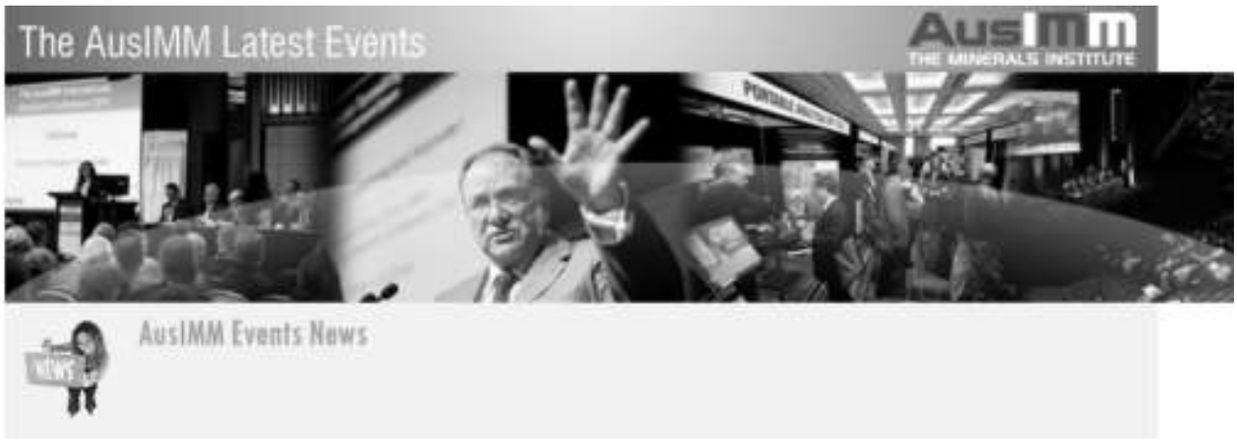
26–29 September 2013 Brisbane
http://www.ausimm.com.au/worldgold2013/papers.asp

Tunnelling and underground space in Europe development
17–19 October 2013, Bologna, Italy
http://www.societaitalianagallerie.it/default.asp

https://events.ausimm.com.au/getdemo.ei?id=187&s=_0L80WJE4A

World Tunnel Congress 2014 and 40th ITA General Assembly
9 – 15 May 2014 — Iguassu Falls, Brazil
http://www.wtc2014.com.br/

World Tunnel Congress 2015 and 41st ITA General Assembly
22 — 28 May 2015 — Dubrovnik, Croatia
http://wtc15.com/



FOCUS ON: Hunter Valley Coal Chain Conference 2013 — Providing attendees access to an impressive line up of industry presenters this conference will enhance a greater understanding of the complexities the coal mining industry faces. This two day program will cover issues on mine exploration, design, approvals, construction, production and case studies on major service providers and customer perspective. Sponsorship opportunities for this event are still available, don't wait contact Event Management now!

CONFERENCE UPDATE: Critical Minerals 2013 — Mines, Markets, Manufacturing and Money. A new conference for AusIMM 2013, this program will explore the expanding demand and supply-side developments in this rapidly emerging sector. Featuring Australian and International Keynote speakers including:

- Jean-Claude Bunzil, Honorary Professor, Swiss Federal Institute of Technology Lausanne, Switzerland
- Judith Chegwidden, Director, Roskill Consulting Group Ltd, UK
- Gareth P. Hatch, Founding Principal, Technology Metals Research, LLC & President & Director, Innovation Metals, USA
- Dudley John Kingston, Executive Director, Industrial Minerals Company of Australia Pty Ltd, Australia
- Mark A Smith, President, CEO and Director, Molycorp Inc, USA

This conference will focus on key solutions to unlocking these issues presented by today's leaders. To participate in this event or to discuss sponsorship and exhibition opportunities, please contact Event Management.

AusIMM Professional Development Seminars 2013

- Money Mining
- Mining geology and grade control course
- An Introduction to cutoff grade estimation: Theory and practice in open pit and underground mines
- Quantitative mineral resource assessments: An integrated approach to planning for exploration risk reduction
- Geostatistical mineral resource/ore reserve estimation and meeting the JORC requirements: Step by step from sampling to grade control
- Ore reserve risk and mine planning optimisation: Stochastic simulation models and applications for the mining industry
- Strategic risk management in mine design: From life-of-mine to global optimisation

AusIMM Co-hosted Events:

- Australian Centre for Space Engineering Researh presents, Off Earth Mining, 20–21 February 2013, Sydney, Australia
- CIM 2013 Convention: Global Leadership... the courage to change, 5–8 May 2013, Toronto, Ontario
- East Asia: Geology, Exploration Technologies and Mines, 27–29 May 2013, Sanur, Bali
- TMS 8th Pacific Rim International Conference on Advanced Materials and Processing, 4–9 August 2013, Hawaii
- 36th APCOM Symposium, 3–8 November 2013, Porto Alegre, Brazil

ATS Tunnel Database

NEW SOUTH WALES

Project:	City Relief Line		
Client: SMA	**Designer** PB/Arup	**Contractor:**	**Supervising Engineer:**
Scope of work:	5km priority tunnel is proposed to be constructed from Eveleigh to Wynyard, separating western services from inner city trains	**Current status:**	Transport NSW is starting alignment and design studies for the project and will investigate a number of alignment and construction options

Project:	Central Coast Rail Upgrade		
Client: TINSW	**Designer** Connell Wagner (Concept) – complete	**Contractor:**	**Supervising Engineer:**
Scope of work:	Hornsby to Hawkesbury. 11.5km twin 8m dia. Rail tunnels	**Current status:**	EIS complete. Unlikely to proceed in short to medium term

Project:	F3 to M2 Road Tunnel		
Client: RMS	**Designer** SKM (preliminary design)	**Contractor:**	**Supervising Engineer:**
Scope of work:	8km road tunnel to connect the southern end of the F3 Freeway with the M2 Tollroad	**Current status:**	Transurban has made unsolicited proposal to NSW Government for consideration

Project:	M5 East tunnel widening		
Client: RMS	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Provision of additional four new lanes in a driven tunnel next to the existing the M5 East tunnel	**Current status:**	Business Case in preparation for completion by June 2013

Project:	M4 East Link		
Client: RTA	**Designer** Connell Wagner	**Contractor:**	**Supervising Engineer:**
Scope of work:	5.5km long, privately funded, road tunnel to connect the eastern end of the M4 Motorway with the CityWest Link.	**Current status:**	On hold awaiting funding

Project:	Inner West Tunnel		
Client: RMS	**Designer** Connell Wagner	**Contractor:**	**Supervising Engineer:**
Scope of work:	5.5km long, privately funded, road tunnel from Taverners Hill to St Peters to connect the eastern end of the M4 Motorway with the M5 East	**Current status:**	Business Case in preparation for completion by June 2013

Project:	F6 Transport Corridor		
Client:	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	20-kilometre motorway from the Sutherland Shire to the city Tunnelled section between Port Hacking Road at Sylvania and Loftus	**Current status:**	Economic Impact Study complete Unlikely to proceed in medium term

Project:	Bells Line of Road		
Client: RMS	**Designer** AECOM	**Contractor:**	**Supervising Engineer:**
Scope of work:	1.2km tunnel to remove 13% grade near Kurrajong	**Current status:**	On Hold

Project:	Busby's Bore Project		
Client: Clean Up Australia	**Designer** KBR	**Contractor:**	**Supervising Engineer:**
Scope of work:	Connection to Busby's Bore and underground water storage in disused St James Railway Tunnel	**Current status:**	Concept design

Project:	Hill M2 Upgrade		
Client: Transurban Group	**Designer** HBO & EMTB in asoociation with T ract Consultants	**Contractor:** Leighton Contractors	**Supervising Engineer:**
Scope of work:	Rock bolting of the existing tunnel. Widening works using an excavator, including widening of the batters (rock walls) on both approaches to the tunnel. Placement of new electrical and services trenches	**Current status:**	Under construction

Project:	South Sydney Freight Line		
Client: ARTC	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	• 30km single track running parallel to the Main South line between Sefton railway station and Macarthur railway station • Cut and Cover tunnel at Sefton. Required to carry the SSFL underneath the existing Bankstown Line • Underground proposal through Cabramatta Railway Station	**Current status:**	Tenders currently being reviewed

Project:	Wynyard Pedestrian Tunnel		
Client: TINSW	**Designer** PB	**Contractor:** TBA	**Managing Contractor** TBA
Scope of work:	$150 million pedestrian access to Barangaroo	**Current status:**	Awarded to Theiss

Project:	City East Cable Tunnel		
Client: EnergyAustralia	**Designer** AECOM	**Contractor:** Theiss	**Managing Contractor**
Scope of work:	3.2km TBM tunnel from Surry Hills to Sydney CBD including connections to existing and proposed substations	**Current status:**	$141 million tender Awarded to Thiess

Project:	North West Rail Link		
Client: TINSW	**Designer** AECOM	**Contractor:** TBA	**Managing Contractor** TBA
Scope of work:	23km long northwest rail link, which includes 15km of deep, underground twin tunnels stretching from Epping to Kellyville	**Current status:**	Tenders close for tunnels and Station Civils contract on 12 Feb 2013

Project:	South West Rail Link		
Client: TINSW	**Designer** SMEC, KBR, GHD	**Contractor:** John Holland	**Managing Contractor** John Holland
Scope of work:	Rail underpass under Hume Highway (80m long) between Glenfield and Leppington	**Current status:**	Detailed Design

Project:	Pacific Hwy Tintenbah-Ewingsdale Upgrade, St Helena Tunnel		
Client: RMS	**Designer** TBA	**Contractor:** Baulderstone Hornibrook	**Managing Contractor**
Scope of work:	Twin 350m long three lane road tunnels.	**Current status:**	Tender awarded to Baulderstone Hornibrook

Project:	Sydney Opera House Vehicle Access and Pedestrian Safety Project		
Client: SOHT	**Designer** ARUP	**Contractor:** John Holland	**Managing Contractor**
Scope of work:	Cavern under Opera House forecourt for loading dock	**Current status:**	Under construction

Project:	Maldon to Dombarton Rail Link		
Client: TINSW	**Designer** TBA	**Contractor:** TBA	**Managing Contractor**
Scope of work:	Long tunnel to provide more direct access to Port Kembla	**Current status:**	On hold

Project:	Northern Beaches Link		
Client: RMS	**Designer**	**Contractor:**	**Managing Contractor**
Scope of work:	Bus tunnel beneath Mosman connecting City with Northern Beaches	**Current status:**	Proposed

QUEENSLAND

Project:	Legacy Way Tunnel		
Client: Brisbane City Council	**Designer** GHD, URS, Cardno	**Contractor:** Transcity – Acciona, Ghella, BMD Construction	**Supervising Engineer:** GHD
Scope of work:	2 x 4km road tunnels from Toowong to Milton. Additional 550m x 4.8m x 4m Conveyor Tunnel (drill and blast) to transport tunnel spoil into Mt Coot-tha quarry	**Current Status:**	The two TBM's Annabelle and Joyce have advanced past half way as at mid-Jan 2013. TBM work expected to be completed by June 2013. Cross-passages in progress. TBM spoil being placed in Mt Coot-tha Quarry and at mid-January above 40mRL (peak is 75 mRL approx)

Project:	East-West Orbital Tunnel		
Client: Brisbane City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel joining Toowong to Everton Park	**Current Status:**	Feasibility study in progress

Project:	East-West Link Tunnel		
Client: Brisbane City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Completion of inner city ring road connecting. 6km from Pacific Highway to East-west Orbital Tunnel (complete 2031)	**Current status:**	Review of traffic demand being completed. Scheduled to be built after 2026 but may be brought forward

Project:	Toowoomba Bypass		
Client: Queensland Department of Transport and Main Roads (DTMR)	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	42km road costing $1B+ will include 735m twin tube tunnel at top of Great Dividing Range	**Current status:**	Pilot tunnel completed. Project on hold awaiting funding

Project:	Cross River Rail		
Client: DTMR	**Designer** TBA	**Contractor:**	**Supervising Engineer:**
Scope of work:	A 19km proposed corridor would include a tunnel under the Brisbane River and new stations, running from Salisbury, in Brisbane's south, to Wooloowin, in the north, via Woolloongabba, the CBD and Bowen Hills. $8.2B project	**Current status:**	Feasibility study is continuing

Project:	Stafford Road Tunnel		
Client: DTMR	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Urban motorway tunnel under Stafford Road to connect the proposed North West Transport Corridor and Inner Orbital with Airport Link	**Current status:**	Planning complete and included in the Western Brisbane Transport Strategy

Project:	Kingsford Smith Tunnel		
Client: Queensland Main Roads	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel to link traffic from the Gateway Motorway and Australia Trade Coast to the Inner City Bypass	**Current status:**	Proposed. Design options developed

Project:	Auchenflower Sewer Upgrade		
Client: Queensland Urban Utilities	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Microtunnelling to install new pipes along Torwood Street, Eagle Terrace, under the railway line into Roy Street and Lang Parade, connecting to the sewer system on Coronation Drive. $9.2m	**Current status:**	Nearing completion, completing final works on sewer maintenance holes in Eagle Terrace, Lang Parade and Roy Street

Project:	Curtis LNG Project		
Client: Santos GLNG	**Designer** Arup	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel crossing to Curtis Island. 4.3kms at 3.4m diameter	**Current status:**	Tender awarded to Theiss

Project:	Bulimba Creek Trunk Sewer Upgrade		
Client: Queensland Urban Utilities	**Designer** Queensland Urban Utilities	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	1.5kn of DN120 pipe jacking 30km of DN800 pipe jacking and 48 manholes	**Current status:**	Under construction

Project:	Wooloongabba Trunk Sewer Upgarde Part B		
Client: Queensland Urban Utilities	**Designer** Queensland Urban Utilities	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	5.2km of sewer pipeline up to 1200mm diameter	**Current status:**	Under construction

Project:	Wooloongabba Trunk Sewer Upgarde Part B		
Client: Queensland Urban Utilities	**Designer** Queensland Urban Utilities	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	Replacing 445 m of rising sewer main and installing 880 m of new gravity sewer main	**Current status:**	A 30 m long DN200 mm pipe was used to jack under Hoya Road

Project:	Arrow Energy Tunnel Project		
Client: Arrow Energy	**Designer** ARUP	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel crossing to Curtis Island. 4.3kms at 3.4m diameter	**Current status:**	Tender in 2013

Project:	Grosvenor Mine Decline		
Client: Anglo-american	**Designer**	**Contractor:** Red Path	**Supervising Engineer:** GHD
Scope of work:	8 m diameter TBM decline for a coal mine, about 1 km long	**Current status:**	TBM under manufacture

WESTERN AUSTRALIA

Project:	Perth Airport Rail Link		
Client: Public Transport Authority	**Designer** AECOM (study)	**Contractor:** N/A	**Supervising Engineer:** N/A
Scope of work:	Twin track electrified passenger heavy rail route from Midland Line near Bayswater Station to a new possible terminal station at High Wycombe. Route to service growing Office and Industrial Park with underground station near current Domestic Terminal. Tunnel options extend under main airport runway to new underground station at International Terminal, continuing eastwards under future runway to High Wycombe (total track length up to 10km, approx half in cut and cover and bored tunnel)	**Current status:**	Pre-feasibility Studies including preferred route identification and preliminary costing, report submitted

Project:	Woodside Browse Gas Pipeline Shore Crossing		
Client: Woodside	**Designer** Atteris	**Contractor:** TBA	**Supervising Engineer:** N/A
Scope of work:	TBM pipejack or segmentally lined tunnel up to 2km length in up to 20m water depth carrying 3 LNG pipelines onshore	**Current status:**	Tenders submitted August 2012

Project:	Sams Creek Stormwater Drainage		
Client: Cape Lamnert Port Authority	**Designer** SKM	**Contractor:** Tunnel Boring Australia	**Supervising Engineer:** NRW-NYFL Joint Venture
Scope of work:	Two rows of 2,100 mm internal diameter pipes approximately 100m long, each with an additional row of 2,100 mm internal diameter pipe for services	**Current status:**	Completed

Project:	Wheatstone gas pipelines Shore Crossing Tunnel		
Client: Chevron	**Designer** Atteris	**Contractor:** Thiess	**Supervising Engineer:**
Scope of work:	TBM pipejack tunnel planned for carrying LNG gas pipelines through surf zone and shore crossing into Plant site	**Current status:**	

Project:	Southern Seawater Desalination Project — Subsea Pipejack Tunnels		
Client: Southern Seawater Alliance	**Designer** An Alliance comprising Water Corporation, Technicas Reunidas, Valorizia Agua, AJ Lucas and Worley Parsons.	**Contractor:** Zueblin Australia	**Supervising Engineer:** N/A
Scope of work:	Three TBM pipejack tunnels approx 900m long under coastal sand dunes (approx 400m) and out to sea (500m). Two Herrenknecht slurry TBMs used with bored diameters 3.0m and 2.4m. TBMs retrieved from below seabed	**Current status:**	Tunnels completed

Project:	Northbridge Tunnel Upgrade		
Client: Main Roads	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Safety system upgrade and tunnel widening	**Current status:**	Replacement of the tunnel's remote control unit (RCU), which controls the tunnel's ventilation fans, fire systems, electronic signs and other features, with a more modern system complete

VICTORIA

Project:	Melbourne Metro		
Client: DoT	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Stage 1 – new rail tunnel between Dynon in the west and St Kilda Road near Domain with new stations in North Melbourne, Parkville, and St Kilda Road. Satge 2 – linking Domain to the Caulfield corridor	**Current status:**	Under review

Project:	East-West Tunnel		
Client: LMA	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential tunnel under Carlton and Royal Park running from the Tullamarine Freeway to the Western Ring Road	**Current status:**	Tender expected 2014

Project:	WestLink — Stage 1		
Client: LMA	**Designer** Aurecon/AECOM/GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	3.5km tunnel stretching from the ports area to Paramount Rd, West Footscray	**Current status:**	On hold

Project:	Hoddle Street Tunnel		
Client: Vic Roads	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:** TBA
Scope of work:	Tunnel would run from the Eastern Freeway to Wellington Parade, near the MCG	**Current status:**	On hold

Project:	Laverton Creek Drainage Scheme		
Client: Melbourne Water	**Designer**	**Contractor:** Trenchless Civil	**Supervising Engineer:**
Scope of work:	Pipe jacking seven DN1,650 mm concrete pipe culverts under the Melbourne–Ballarat rail corridor	**Current status:**	Boring completed in early December 2012. Remaining works to construct concrete headwalls and finish floodway excavation are due for completion in April 2013

Project:	North East Link		
Client: LMA	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential road tunnel from Greensborough to Bullen linking the Western Ring Road to the Eastern freeway	**Current status:**	Not before 2018

Project:	Bendigo CBD		
Client: VicRoads	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	A 3.5km road tunnel under the Bendigo CBD	**Current status:**	Proposed

SOUTH AUSTRALIA

Project:	Carrapateena Exploration Decline		
Client: OZ Minerals	**Designer** Aurecon	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Exploration decline to be constructed by TBM	**Current status:**	Four contractors shortlisted to Tender Q1 2013

Project:	Adelaide Glass Tunnel		
Client: Port Adelaide City Council	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Glass tunnel along the bed of the Port River directly beneath the Birkenhead Bridge to allow tourists a closer look at the Port River dolphins	**Current status:**	Proposed

TASMANIA

Project:	Hobart City Tunnel		
Client: Hobart City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel from the Southern Outlet at Davey St to Brooker Ave under West Hobart and North Hobart, and a second stage through the Queen's Domain to the Tasman Bridge	**Current status:**	Cancelled due to cost

NEW ZEALAND

Project:	Homer Tunnel Upgrade		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Extra safety improvements include an extra satellite phone, thermal and infrared cameras, and live monitored video streaming	**Current status:**	In planning

Project:	Britomart rail loop		
Client: Auckland Regional Transport Authority	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	A 3.5km loop linking Britomart with the current western line. Three new underground stations at Aotea Square, Newton and K' Road	**Current status:**	Planning and conceptual design in progress

Project:	Waterview Connection		
Client: NZTA	**Designer**	**Contractor:** Fletcher/MacConell Dowell/Obayashi	**Supervising Engineer:**
Scope of work:	5 km Waterview Connection, including two 2.4km tunnels between Owairaka and Waterview, to provide a new six-lane motorway link between SH16 (the Southwestern Motorway) and SH20 (the Northwestern Motorway) to complete Auckland's Western Ring Route	**Current status:**	Ceremonial ground-breaking for a 30 metre deep trench needed for the construction of the project's twin tunnels carried out in August 2012. Tunnelling to commence in 2013

Project:	Milford Dart Tunnel		
Client: Milford Dart Co.	**Designer** URS	**Contractor:**	**Supervising Engineer:**
Scope of work:	10.2kms of 5m diameter tunnel for single lane bus route or rail	**Current status:**	In planning

Project:	North Bank Tunnel		
Client: Meridian Energy	**Designer** URS	**Contractor:**	**Supervising Engineer:**
Scope of work:	36kms of 12m diameter headrace tunnel & hydro power station	**Current status:**	In planning

Project:	Britomart rail loop		
Client: Auckland Regional Transport Authority	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	A 3.5km loop linking Britomart with the current western line. Three new underground stations at Aotea Square, Newton and K' Road	**Current status:**	Planning and conceptual design in progress

Project:	Wellington Northern Corridor		
Client: NZ Transport Agency Board	**Designer** AECOM, Parsons Brinckerhoff and Beca	**Contractor:**	**Supervising Engineer:**
Scope of work:	Four lane expressway from Levin to Wellington Airport including duplication of Mount Victoria and Terrace tunnels	**Current status:**	In planning

Project:	Tauranga Tunnel		
Client: Local Govt	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Three routes for a road tunnel through the Kaimai Ranges, linking Tauranga with the Waikato	**Current status:**	Currently being investigated by the NZ Transport Agency

Project:	Central Interceptor Project		
Client: Local Govt	**Designer** AECOM	**Contractor:**	**Supervising Engineer:**
Scope of work:	New sewer tunnel approximately 14 kilometres in length from central Auckland to Mangere Wastewater Treatment Plant	**Current status:**	Design in progress — construction to be completed by 2025

Project:	Nevis Tunnel		
Client: NZ Transport Agency	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel to replace a rockfall-prone stretch of highway at the Nevis Bluff, midway between Cromwell and Queenstown	**Current status:**	Concept

Project:	Welcome Bay Tunnel		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel or roundabout proposed	**Current status:**	Proposed

Project:	2nd Mt Victoria Tunnel		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel and road widening of three Hataitai roads — Taurima St, Ruahine St and Wellington Rd — to create a four-lane road from Wellington urban motorway to the airport	**Current status:**	Proposed 2018 construction start

Project:	Hunua 4 Watermain Project		
Client:	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	30 kms of 1.3 to 1.9 metre diameter steel pipeline traversing Manukau and Auckland cities including the crossing of Manukau Harbour, three motorways, three railway lines, a creek and eight streams	**Current status:**	To date 324 m of pipe work has been completed. The main construction is started in early 2012 and final commissioning is expected in 2016

Project:	Watermata Harbour		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Potential tunnel route between the central city and the North Shore would cost from $4 to 5.3 billion	**Current status:**	Concept

Project:	Welcome Bay Tunnel		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel or roundabout proposed	**Current status:**	Proposed