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THE DAVID SUGDEN YOUNG ENGINEERS WRITING AWARD 2011

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Win a chance to attend the 2012 ITA World Tunnel Congress in Bangkok, Thailand with accommodation

- The competition is open to all ATS Members and University Students under 35 years of age (as at 30 June, 2011)
- 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 2011
- Winner announced by 31 August, 2011
- 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 Bangkok, Thailand from 18–23 May 2012.

The winner may also be invited to be a member of the ATS Executive Committee for 12 months as the Young Engineers Representative.

For more information contact Sheryl Harrington at the ATS Secretariat
Phone 1300 653 113 — Email: sharrington@engineersaustralia.org.au

Cover photo:
Victoria Park Tunnel, Auckland New Zealand — Courtesy of Victoria Park Alliance

Australasian Tunnelling Society is sponsored by Engineers Australia and the Australasian Institute of Mining and Metallurgy.

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

Chairmans Report

We are currently reviewing our rules and regulations in line with good governance. The appointment of Sheryl Harrington our new EA Committee Administrator has had a major impact with this as she has had significant previous experience in best practice. It is anticipated that our efforts will form a template for other technical societies under the Engineers Australia umbrella.

The National Executive Committee will be meeting in Auckland before our conference in March to vote on the adoption of the new rules and regulations. As a technical society sponsored by Engineers Australia and the Australian Institute of Mining and Metallurgy the rules will be subject to ratification by both these organisations.

Simon Knight — Chairman ATS

EDITOR'S NOTE

This is our Special for the ATS Conference and as it is our first conference in New Zealand we have made this a focus on New Zealand. All of ATS were much aggrieved by the disaster at Pike River and our thoughts and sympathy go out to their families. I was pleased to receive some news articles from other members which I have published in the news section. Please feel free to send me any articles you may care to publish. Remember this is your Journal.

David Lees — ATS Editor

Australasian Tunnelling Society website

www.ats.org.au

AUSTRALASIAN TUNNELLING SOCIETY

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14th AUSTRALASIAN TUNNELLING CONFERENCE

First time in New Zealand – a unique opportunity for all interested in the development of the Underground Space

When: 8th to 10th March, 2011

Where: Sky City Conference Centre

Make sure that you attend the pre-eminent tunnelling colloquium for Australasia. A truly European flair will be enjoyed through the participation of Professor Giovanni Barla, Turin Polytechnic University, who is one of the keynote speakers at the conference. Giovanni never fails to infuse his audience with his enthusiasm and love for underground soil/rock mechanics and we look forward to his address. Giovanni will also lead a pre-conference short course; an opportunity for immersion into European thinking and approaches.

Many advances have been achieved across the Asian scene and Alan Morris, Project Manager for the XRL Tunnels, MTR Corporation Ltd, Hong Kong will provide an overview of these while also outlining his views on where our industry finds itself in terms of technical developments.

Our third keynote speaker, Professor Arnold Dix, Chairman of the ITA Contractual Practices group and Australian delegate to PIARC in tunnel ventilation, safety and environment will address operational issues in particular in vehicular tunnels.

CLICK TO VISIT THE CONFERENCE WEBSITE AND REGISTER ONLINE
www.atstunnellingconference2011.com

Pre-Conference half day course on Face Stability Analysis and Support in Tunnelling by Professor Giovanni Barla, Turin Polytechnic University on Monday 7th March 2011.

Time: 1.30pm – 6.00 pm

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Victoria Park Tunnel

Why does a tunnel need to be provided?

The Victoria Viaduct was constructed during the early 1960's to link the Southern Motorway to the Auckland Harbour Bridge , replacing the link via Nelson Street and Fanshawe Street to the St Mary's Bay section. Today it carries an average of 105,512 vehicles a day.

Currently the four lane layout proves to be a bottleneck on both sides of the bridge. Traffic regularly backs up due to traffic entering at the North Western Links and Wellington Street on the southern side. On the northern side traffic flow is impeded by lane changes into the only two available southbound lanes, and further affected by traffic wanting to then exit directly after the viaduct at Cook Street and Northern to North West Links.

As the bridge was completed in 1962 and has not been retrofitted, compared to the AHB, it has issues such as Concrete Cancer (Alkali Aggregate Reaction), does not match earthquake standards, it has poor safety standards like cambers, geometric's, stopping space and barriers

Four options were proposed for the upgrade of the Victoria Park corridor. Namely: widening the existing viaduct, a sunken motorway, full two way tunnel or keeping the viaduct with a northbound tunnel. The partial tunnel option was chosen.

There will be three stages of the construction, where the tunnel will be built, opened to northbound traffic, then all four existing lanes on the Viaduct will open to southbound traffic.

Once open, three northbound lanes will be open through the tunnel which will connect with the St Mary's Bay section where it will become five lanes. The southbound lanes will use all of the existing Victoria Viaduct lanes, equalling four lanes for southbound traffic. These lanes will be split into direction being; the two left lanes will be allocated for Cook Street and Northern to North Western link. The other two far lanes will be for southbound traffic.

Sound issues, aesthetics and previous problems with the existing viaduct will be addressed and once needed a southbound tunnel will be constructed and the existing Victoria Viaduct will be demolished. One of the reasons why the southbound tunnel will not be built with this project is because of a possible tie-in with the third harbour crossing, and a compromise between benefit to cost ratio.

Construction update

Excavation of the Victoria Park motorway tunnel has reached the halfway point with the meeting of the diggings north and south of Beaumont Street in central Auckland.

The breakthrough allows a walk through 300 metres within the tunnel trench – from the tunnel's northern portal, under Beaumont Street and through Victoria Park to Victoria Street West signaling the halfway point of construction of the 'cut and cover' tunnel structure.

The tunnel is a major component of the $340 million Victoria Park Tunnel project to remove the last remaining traffic bottleneck on the central Auckland motorway network. When it opens in mid-2012, the tunnel will carry three northbound lanes while the existing Victoria Park viaduct will be reconfigured to carry four southbound lanes.

The project will be the first of the Government's seven Roads of National Significance, identified as essential to the New Zealand's economic prosperity, to be completed. Mr Parker says it will provide more reliable travel on the country's busiest route for freight and business travel.

More than half of the tunnel's 360 30-tonne roof beams are now in place and sections of tunnel roof have already been completely closed in along with many of the tunnel's 52 floor slabs. The tunnel base is made from 36 tonnes of reinforcing and 200 cubic metres of concrete per slab which will be covered with tarmac to create the road surface inside the 450-metre-long tunnel.

Work has also begun on installing lighting, communications, fire protection and emergency exits.

Landscaping and planting to restore Victoria Park on top of the tunnel is planned to take place in autumn and winter next year.

Good progress is also being made at the southern end of the 450-metre tunnel where traffic and major drainage, electrical and communications services have had to be relocated away from the path of the tunnel.

Victoria St West end of Franklin Rd has been realigned close to its original position, but now runs over tunnel roof slabs.

The Rob Roy Hotel is due to be moved back to its original site, which will be on the roof of the tunnel, in March 2011 and all tunnel construction in this area completed in April.

The Rob Roy Hotel is due to be moved back to its original site, which will be on the roof of the tunnel, in March 2011 and all tunnel construction in this area completed in April.

Once completed, the tunnel will help carry traffic north to the Harbour Bridge while the existing flyover will take traffic south. NZ Transport Agency spokesman Tommy Parker said the project reached a milestone by staying on track and on budget for its finish date in the middle of 2012.

Tunnel construction manager Mike Wall said the tunnel had been "an incredibly fast-moving project and it's as much of a problem to keep up as it is to get ahead." But the quick work has not come at the expense of safety, which has been paramount for workers building the tunnel. Gloves have also been issued to all workers to avoid any contact with the soil that may have been contaminated by an old gas works that operated around there at the turn of the century.

Auckland rail tunnel

The $2 billion rail tunnel through central Auckland is expected to be completed within seven years, but how it will be financed is still in question.

A report on which the proposal is based says the standard benefit-cost ratio (BCR) for the project is equal or higher than that of two of the Government's Roads of National Significance.

The tunnel is seen as vital as it would turn Britomart from a dead-end station to a through station, thus making it possible to run many more trains in Auckland. The link would double the number of trains that can go through Britomart, let Aucklanders get around the region more easily, and reduce congestion on our roads. The potential urban redevelopment and additional growth derived from investment in this infrastructure would make the project transformational not just for Auckland, but for New Zealand as a whole.

The tunnel would include new stations near Aotea Square (which could become busier than Britomart), Karangahape Road and Newton. Mr Brown said the report suggests there is a strong case for proceeding immediately with protecting the route, funding the protection process and further investigation of funding the tunnel.

As much of the route would be underground, affected landowners would need to be consulted about potential impact to their properties. The report suggests that without the link, the central business district would require twin or triple bus lanes in both directions on most road corridors.

What the loop will involve:

- A 3.5 km loop linking Britomart with the current western line.
- Three new underground stations at Aotea Square, Newton and K' Road.
- Most of the CBD will be no further than 500 metres from any CBD station.
- Double the number of trains will go through Britomart.

Mt Vic upgrade

An urgent safety upgrade of Mt Victoria tunnel is facing delays despite roading officials identifying a serious risk of injury or death in the event of a tunnel fire.

The New Zealand Transport Agency announced plans in February 2010 for an $80 million refurbishment to remedy fire safety concerns in The Terrace and Mt Victoria tunnels. About 40,000 cars use each tunnel daily, and the agency has said it is "untenable" not to deal with the safety risk "with all possible speed".

Despite the warnings, it is understood the Mt Victoria tunnel upgrade is being put off while decisions are finalised for roading options around the Basin Reserve.

NZTA state highways manager Rob Whight said planning for the Mt Victoria upgrade was taking time. "The upgrade of the Mt Victoria tunnel's fire and safety systems remains a top priority for the ... agency. It is important we closely examine the merits of all possible options to ensure we take the right course of action."

It is understood that the options include the building of a tunnel for the inner-city bypass from the city side of Taranaki St to the Mt Victoria tunnel. This would replace a proposed Basin Reserve flyover and allow space for a planned Buckle St Memorial Park.

NZTA is also investigating whether a proposed second Mt Victoria tunnel should go to the north or south of the existing tunnel. A northern tunnel could be built alongside an existing pilot tunnel, which would then be used as an escape route in emergencies. The pilot tunnel could eventually become a pedestrian-only route between the city and eastern suburbs.

The Terrace Tunnel upgrade, however, appears to be a step closer. NZTA has applied to Wellington City Council for consent to build a temporary site office and workshop on the corner of Buckle and Tory streets to operate for up to five years.

It is understood the workshop would make components required for the tunnel upgrades. The components would then be taken by truck to the tunnel, which would be closed nightly.

Mr Whight said, "[We are] still assessing options in regards to the timeframes of the tunnel refurbishments and related traffic changes, and the nature of the work involved."

Ad Feedback NZTA investigations last year found that ventilation, fire suppression, linings, lighting, drainage and emergency systems in both tunnels lagged well behind modern international standards. Some earthquake strengthening work is also required.

Harihari power scheme under way

Work to rebuild a hydro power scheme on the Amethyst River, near Harihari, is on track with a 1.8km road now formed to the tunnel portal site. Westpower says about 4000 South Westland homes will benefit from the development of the 6MW scheme, which is a joint venture between Westpower and Harihari Hydro Ltd. It is expected to be operational by 2013.

Westpower chief executive Rob Caldwell says the project is running to schedule, with tunnel contractors now having access to the operational site.

The extra generation would provide a "steep change in security of supply", both south to the glaciers and north to Hokitika.

The Amethyst River, a small tributary of the Wanganui River just east of Harihari township, was the site of a small hydro station that opened in 1954 and was shut by Westpower in the late-1980s. Mr Caldwell said the old plant had become unviable and needed major works to the entire scheme for it to run safely.

However, tourism and farming activity in Westland, and recent legislation amendments to enable line suppliers to operate generation schemes, led the power company to reinvestigate the Amethyst scheme, together with Harihari Hydro Ltd, which had a 20% stake in the scheme.

Although parts of the old hydro scheme are still visible, none of it will be touched for the rebuild. Under the new scheme, the powerhouse will be located about 1km north of the old one, with water diverted into the Wanganui River rather than the Amethyst.

The consent involves the clearance of 3.6ha of vegetation, a construction period of over 12 months and associated blasting noise. Land consent covers the construction of a 1.1km tunnel, access road and a 2.5km penstock, which will mostly be buried underground.

Proposed Kaimai tunnel

Three routes for a road tunnel through the Kaimai Ranges, linking Tauranga with the Waikato, are being investigated by the NZ Transport Agency.

NZTA regional director Harry Wilson says one option involves building a road tunnel near the existing rail tunnel, another is building a tunnel near Thompsons Track, between Katikati and Apata. The third option, known as a summit-level tunnel, involves building a tunnel half-way up the existing alignment of State Highway 29.

So far 10 options have been identified in these three locations.

"To date, high-level cost estimates indicate the price for each option including approach roading would range from $1.5 to 2 billion," Mr Wilson said. "While we are not discounting the possibility of building a tunnel, the early indication from the cost-benefit analysis shows that the cost of building a tunnel could outweigh the benefits of the project."

Mr Wilson said once the benefits from the Waikato Expressway were realised – moving traffic more efficiently and safely from Auckland to south of Cambridge – the NZTA expected traffic volumes to increase to a level where the rest of the route forming the "golden triangle", between Tauranga, Hamilton and Auckland, would need upgrading.

New Zealand Road Transport Forum chief executive Ken Shirley said the time and fuel efficiency of a road tunnel, combined with a predicted 70 per cent increase in freight being transported by road and rail over the next 25 years, may well mean a tunnel stacked up in 20 years. For something as strategic as this tunnel in the "golden triangle", Mr Shirley said all the highways linking to the tunnel, and exactly where it was positioned, also needed to be considered.

Tauranga economic growth agency Priority 1 chief executive Andrew Coker was supportive of further exploration of the idea between industry and NZTA and keen to be involved and understand some of the decision making that was happening. However, he said the tunnel "sounded very expensive" and the existing road could be upgraded for significantly less cost.

The announcement has been welcomed by the New Zealand Road Transport Forum, which had been urging the Government to look at a tunnel.

Derek Dumbar, the forum's Waikato/Bay of Plenty director, said the agency's costs were much higher than the tunnel investigation carried out by consultants Connell Wagner for the forum in 2008. He said Connell Wagner's cheapest option, at the narrowest point of the Kaimais south of Katikati, was just over half a billion dollars for a tunnel 1.2km long.

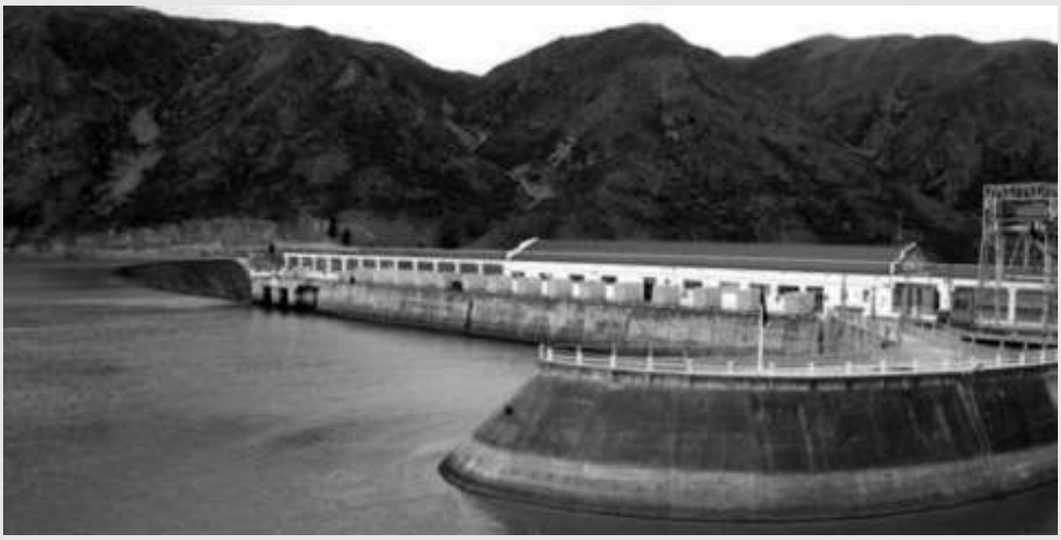
It meant the Katikati bypass would not be required because all Auckland traffic would use the tunnel.

Mr Dumbar has been promoting the tunnel for nearly three years with the idea that the Port of Tauranga would become the North Island's major port. He said the heavy transport industry would be prepared to pay tolls to use a tunnel. Tauranga Mayor Stuart Crosby said the tunnel was absolutely critical to the port becoming New Zealand's number one port.

Homer Tunnel Safety Improvements

Professional services tenders have been called for investigation and reporting phase of the Homer Tunnel Safety Improvements contract. Services include indentifying and developing safety improvements for the Homer Tunnel. Improvements for investigation include tunnel widening, ventilation, lighting, fire safety systems and emergency egress facilities.

The Homer Tunnel runs beneath the Homer Saddle within Fiordland National Park. Construction began in 1934 and, following delays during World War 2 and for avalanche damage, it opened in 1953. The 1.27km long tunnel has a 10% gradient and varies in width from 6.5m to 7.5m. At the height of the summer tourism season it is used by more than 100 tour buses a day.



NORTH BANK TUNNEL PROJECT

Meridian Energy has been granted consent to use water from Lake Waitaki for its proposed $1 billion – a 12-siameter, 36km-long underground tunnel providing electricity for 175,000 homes in Otago and Canterbury.

The North Bank Tunnel Concept is a hydro generation proposal taking water from Lake Waitaki and discharging it back into the Waitaki River about 34 km downstream near Stonewall.

Meridian Energy's investigations to date have shown that there is potential for a viable tunnel concept if the water resource can be secured. This staged consenting approach ensure that the essential resource, the water, is available before millions of dollars are invested on detailed engineering investigations and to ensure the community has the opportunity to understand and have input into the concept as it develops. The water-only consents do not authorise the construction of the tunnel or any power station.

The scheme would extend from the Waitaki Dam to Stonewall. Over this distance the river drops about 125 metres and it is this elevation drop, or head, that would be utilised by the tunnel concept to generate electricity. The consents is for a water take at Lake Waitaki and water discharge back into the Waitaki River at Stonewall on the north bank opposite and upstream of Black Point.

A monthly flow regime is proposed for the Waitaki River based on the variable, seasonal in stream and out of stream values and the electricity demand cycle. The minimum flows vary between 110 and 150 cumecs.

However, the plans hit a snag when tests recently revealed issues with the geological structure along the central part of the tunnel's proposed route along the lower Waitaki River.

"The composition of the rock would propose challenges, and also there were some faultlines that would cause some issue as well," Meridian spokeswoman Claire Shaw told NZPA. Drilling around faulted rock just makes the process of actually digging this full tunnel more difficult. It would take longer, it might be harder, there'll be lots of different risks associated with it."

The company has proposed an alternative design, replacing the midsection of the tunnel with a 13km-long canal. Shaw said it was too soon to tell whether the redesign would end up costing more. "We've always mooted it as a billion dollar-plus project, and until we have the final design, and, to be honest, until it's built, it's very, very difficult to give a cost."

The company was in the process of discussing consent issues with landowners, said Shaw. "We're concentrating on letting the landowners absorb the information we've given them, and we'll be waiting to hear back from them, so it's very early days yet."

Mrs Shaw said the prompt for the proposed change was the result of a thorough programme of studies, not the recent 7.1M Christchurch earthquake. "The seismic activity in this area, like all areas, is taken into account.

The Christchurch earthquake was not related to the planning for this in any way. This area of the Waitaki is actually a low seismic area, not as active as Christchurch." The changes would not alter the projected level of generation, which would remain at 1400 gigawatts a year, or enough to power Christchurch, she said.

Hydro for Stockton Plateau

Hydro Developments Ltd (HDL) and Solid Energy New Zealand Ltd have reached an agreement about using water from Stockton Plateau to generate electricity. The agreement clears the way for HDL to progress its hydro-electric scheme at Stockton alongside Solid Energy's mining operation on the plateau.

Hydro Developments gained resource consents in January 2010 for a hydro scheme at Stockton. Solid Energy appealed that decision, concerned that the HDL scheme could compromise its ability to efficiently and economically mine at Stockton. Solid Energy was not successful with its application in June 2010 to gain consents for an alternative hydro-electricity proposal and has appealed that decision. Solid Energy is continuing to pursue its own appeal but accepts that any consents granted will be subordinate to the consents for the HDL scheme. As a result of today's agreement, Solid Energy and HDL will abandon their appeals of the other's scheme.

Solid Energy will now provide HDL access to the land it requires and HDL has agreed not to oppose any consent applications for water diversions Solid Energy may require for the efficient operation of its coal mining operations at Stockton.

HDL Director, Ant Black, and Solid Energy Chief Operating Officer, Barry Bragg, say the agreement addresses both sides' concerns and smoothes the way for HDL to continue developing its proposal.

"It's been a somewhat convoluted route to what is an equitable and good-spirited outcome," Ant Black says. "HDL is excited about progressing the project and is looking forward to an improved and cooperative relationship with Solid Energy."

Barry Bragg says Solid Energy too is looking forward to working with HDL as it moves its project forward. "We are pleased we've been able to come to an agreement, particularly on Solid Energy's right to use water for current and future mining and at the same time giving land access to HDL so they can take their project forward."

More gold under the Waihi hills

A lot more gold is likely to come out of the ground under the small Bay of Plenty gold mining town of Waihi in the next year or two.

The gold mining company which re-activated the Martha's Hill mine behind the town more than 20 years ago, plans to open up three new veins of gold-bearing ore which it said had the potential to produce about 200,000 ounces of the precious yellow metal over three years.

The Trio Project had the potential to produce about one million tonnes of ore for the 200,000 ounces of gold.

Newmont Gold spokeswoman, Linda Willougby said the company expected resource consent to process the ore to be granted by 2012 and the Trio, Aramanth and Union veins would be mined for about three years.

The project was expected to cost about $122m a year. Of that, $38m would be spent in Waihi, $52m would be spent in the Hauraki District region and $20m would be spent nationally. A further $11m would be spent offshore.

The company said the project would generate 184 jobs and for every person employed at the mine, there was another person in the town or nearby district who relied on the mine for a job.

The three veins would be underground mines up to 330 metres deep and would be dug from the Favona portal to the east of the Waihi township.

Mining from the Favona mine was expected to end in 2011 and the new mines would start the following year. No houses were built above the gold-bearing veins which would be mined.

Newmont said because the new mine was underground there would be little additional noise apart from a new vent on Union Hill but noise from that fan would be below stringent limits imposed by the Hauraki District Council.

Vibration from blasting and mining would also be well below the "threshold of damage" — the level that would cause either cosmetic or structural damage to nearby properties, Newmont said.

A public hearing on the company's land use application was held in December.

Applications for the Trio Project had also been with Environment Waikato and with Crown Minerals. The applications related to a range of other resource consents and a variation to the mining licence.

Pike River Coal

Pike rescuers saved by timely decision

The PRC tag board with 29 miners who never came back.

Rescue teams were called off from entering the Pike River Coal mine around seven minutes before the second explosion took place.

Five days after the initial explosion on November 19 which left 29 miners missing, NZ Mines Rescue teams were anxious to enter the mine. But the exercise was halted when gas analysis revealed another explosion was imminent.

The second explosion minutes later was much bigger than the first and ended hopes for any more survivors.

The 2.3-kilometre drift access tunnel was the only way in and out of the mine. The miners all had self-contained self-rescuers but these would provide just 30 minutes of oxygen, but no continuous gas monitoring system was in place at the mine.

The borehole which intersected an area where the miners were thought to be provided a gas reading of 95% methane, according to the sources, with carbon monoxide making up most of the remaining gas.

Pike River could be sealed

Sealing the Pike River mine in New Zealand is one option being considered as Pike River Coal's receivers present alternative re-entry plans.

Receivers PriceWaterhouseCoopers will provide NZ Police with the re-entry plan to recover the bodies of the 29 miners who died after explosions in the mie, as families grow increasingly impatient with the pace of the recovery, however it is ultimately the police's decision as to whether to proceed with the re-entry plan, he reportedly said.

"The most important thing that needs to happen immediately is for the atmosphere in the mine to be safe so that people can enter it, and until that's achieved no further steps can be taken,"' he told Radio New Zealand. Closing the mine "could be the ultimate outcome" if the plan failed and "all we can do is really try and facilitate a process and we're putting every effort we can into doing that".

A site inspection by Canterbury University professor David Bell confirmed that efforts to inertise the mine using the GAG machine could take a "very long time" and that if that proved unachievable with current methods "sealing the mine remained an option", NZ Police operation commander superintendent Gary Knowles said.

The GAG machine brought over from Queensland, which has been pumping water vapour into the mine, and a Floxal nitrogen generator to cool the mine have been criticised for taking too long to make the mine safe enough for re-entry and extinguish any remaining coal fires.

The GAG jet engine started up at the troubled mine in December 2010, and has never faced such a long tour of duty. The engine was running well, but there were natural concerns about the life of the jet engine as it has been going for more than 600 hours. The turbine of the jet engine has been put to the test, but so have the GAG

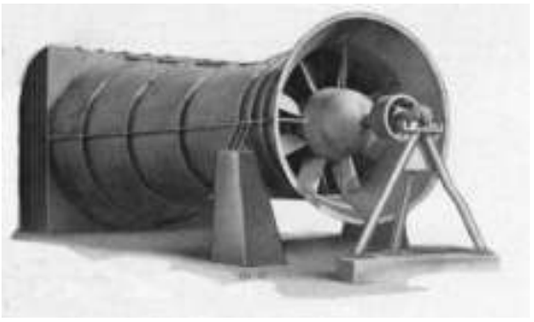
crews who have been working around the clock right through Christmas and New Year's Day. The experience has provided QMRS with insight into running the GAG for prolonged periods. Managing the "fatigue factor" for crews and trying to align maintenance schedules with "strategic decisions" are some of the lessons learned. But the operation of the GAG could continue for many weeks, despite the expense. The jet engine consumes around 1800 litres per hour at an average run time of 20 hours per day.

With no option to enter the mine since the explosions, a tube bundle system was brought over from Queensland and an overland gas monitoring system was established using boreholes and shafts. While some readings have registered zero methane as the GAG operated, the exposed coal underground is causing more methane to accumulate at the back of the mine.

GAG – Ventilating Mines with Repurposed Airplane Engines

The Gorniczy Agregat Gasniczy (GAG), as it's known, is "a jet engine inertisation unit developed for use in mines, controlling and suppressing coal seam fires," it is literally a jet engine that you plug into one end of a sealed mine in order to blow high-powered chemical winds (carbon dioxide, nitrogen, and water vapor) into the tunnels below. These gases then "lower the oxygen levels, suppressing fires and forcing methane out of the mine."

There are only three operational GAG units in the world. Each operates by taking a "docking position" on the earth's surface, attached to "intake ventilation headings"



that lead, via boreholes, into the porous labyrinth of artificial caves below. The GAG then rapidly pumps a new atmosphere into the existing mineworks, as if generating artificial weather underground. A variation of this device was used, mounted on a remotely controlled tank, to extinguish the oil well fires in Kuwait following the Gulf War."

Pike River tragedy threatens all underground mining in New Zealand

The future of New Zealand's entire underground mining industry was in doubt following the Pike River colliery disaster that claimed 29 lives, Prime Minister John Key said. The industry, which has enjoyed a boom in recent years thanks to surging demand from Asia, could not continue if there was a risk of more tragedies such as this month's Pike River pit explosion, according to Key.

Announcing he wanted a powerful Royal Commission to investigate the disaster, Key said: "In the end, the future of Pike River and actually underground coal mining in New Zealand rests on this. We can't put people into mines that are dangerous." He said there were four underground mines in New Zealand and about 450 people were directly involved in the industry.

However, the wealth generated by the industry as Chinese and Indian steelmakers clamour for New Zealand's high-quality coking coal means it is a major economic driver in small mining communities across the nation.

Key said he would ask parliament to set up a Royal Commission into the mine explosion at the remote South Island pit on November 19th 2010. Another blast eliminated any hopes for the miners' survival, and a third followed. The colliery, which opened two years ago, remains flooded with explosive methane gas, preventing emergency crews reaching the miners' bodies entombed within.

Key said the Royal Commission — the most powerful investigation available under New Zealand law — would be headed by a judge and have the power to compel witnesses to testify. It would be the first Royal Commission to investigate a disaster since a probe into an Air New Zealand crash in 1979.

"There are serious questions that need to be answered," he said, vowing the enquiry would leave "no stone unturned" to find the cause of the blast.

Pike River Coal executives have expressed hope the mine will eventually reopen but Key said that was unlikely to happen until the Royal Commission was complete, a process that could take more than a year. "It can't and won't reopen until we've identified what's caused the build up of methane," he said.

HOMER TUNNEL

The Homer Tunnel is a road tunnel in the Fiordland region of the South Island of New Zealand, opened in 1954. It links Milford Sound to Te Anau and Queenstown, by piercing the Main Divide at the Homer Saddle. It connects between the valley of the Eglinton and Hollyford Rivers to the east and that of the Cleddau to the west.

The tunnel is straight, and was originally single-lane and gravel-surfaced. The tunnel walls remain unlined granite. The east portal end is at 945 m elevation; the tunnel runs 1270 m at approximately a 1:10 gradient down to the western portal. Until it was sealed and enlarged it was the longest gravel-surfaced tunnel in the world

William H. Homer and George Barber discovered the Homer Saddle on January 27, 1889. Homer suggested that a tunnel through the saddle would provide access to the Milford area.

Government workers began the tunnel in 1935 after lobbying by J. Cockburn of the Southland Progress League. The tunnel and the associated Milford Road were built by relief workers during the Depression, initially just starting with five men using picks and wheelbarrows. The men had to live in tents in a mountainous area where there might be no direct sunlight for half of the year. At least three were killed by avalanches over the coming decades

Progress was slow, with difficult conditions including fractures in the rock bringing snow flows into the tunnel. Compressors and a powerhouse in the nearby river were eventually built to pump out 40,000 litres of water per hour. Work was also interrupted by World War II (though the actual piercing of the mountain had successfully been achieved in 1940), and an avalanche in 1945 which destroyed the eastern tunnel portal. These problems delayed the tunnel's completion and opening until 1954.

In 2002 a tour bus carrying tourists from Singapore caught fire inside the tunnel, halting 150 m from the eastern portal. The passengers and the bus driver had to tread through the pitch-dark and smoke-filled tunnel to safety with the help of head beams from vehicular traffic at the entrance of the eastern portal. However, two passengers got separated and made their way to the Milford end. Three people were flown to Southland Hospital and treated for smoke inhalation. A satellite phone and fire extinguishers were installed in the tunnel as a result of this incident. Two tourist buses were destroyed by fire outside the tunnel in January and March 2008, though the fires were not related to the tunnel.

Roof lighting was fitted and traffic lights reintroduced in 2004 to reduce capacity constraints and safety issues. Although the tunnel is large enough for a bus and a smaller vehicle to pass, meetings involving two coaches or campervans are problematic.

This is alleviated by the fact that the traffic is very tidal, towards Milford Sound in the morning and toward Te Anau in the afternoon. The traffic lights operate only during the peak summer season, since the avalanche risk makes it unsafe to stop and queue at the portals in winter and spring. With increasing traffic on the road, it is expected that the risk to vehicles waiting at the portal will also increase

A widening of the tunnel, to allow for true two-laning, has been discussed. While this would make it unnecessary to force cars to wait in the avalanche areas, the high costs make this unlikely, especially for a road which carries little traffic. Avalanche warning systems in the area are also considered to meet typical worldwide standards. In addition, Transit New Zealand is considering the realignment of the Homer east portal avalanche shed.

Hataitai Tram/Bus Tunnel

As the population of Hataitai increased at the end of the nineteenth century residents began demanding better access to the suburb. Before the tunnel was built access was via Newtown and Crawford Road, or by negotiating the road around the coast from Evan's Bay or tracks over Mt Victoria. In 1899 the *Evening Post* carried reports that residents of Kilbirnie were agitating to have the road from Newtown flattened so that trams could use it.

By 1904 there was a strong movement demanding a tunnel, and the Post reported a lively meeting of 100 people discussing the issue. It was said a tunnel would shorten the distance from North Kilbirnie (ie Hataitai) to the city by two-thirds of a mile. Residents pointed out that the spoil from the tunnel could be used for improvements in Kilbirnie, and said the Council would gain income in rates if more people were encoraged to settle in the district. The Hataitai Land Company in particular pushed for a tunnel, as this would improve the value of its sections. Eventually plans were made and the Hataitai Land Company donated almost £10,000 towards the cost. Kilbirnie School had a half-day holiday when Richard Seddon turned the first sod on the Hataitai side on 18 October 1905. Charlie Taylor was a boy at the time and recalled in his memoirs:

> *"The tunnel was dug by pick and shovel and explosives, the earth put into iron trucks and sent rolling down hill on the rails laid down Moxham Avenue to Evans Bay, where the Recreation Grounds are now, and the spoil taken out of the tunnel was tipped there to make an extension of the Reserve. Then horses would hitch on and haul the trucks back up on the other line. There was a man on the trucks going down who operated the brakes and the same man rode back on the trucks to get more spoil. There were no motor lorries or bulldozers, just man power."*

The 1200ft-long tunnel took 18 months to build. A slip occurred during construction which killed three men and injured another. This caused delays while the debris was cleared, but work was finished on 11 April 1907 at a total cost of £15,834. The new tramline through the tunnel was tested the next day and officially opened to the public on 16 April 1907. A single-deck car was used for the test, and the run was a smooth one. The Mayor and Mayoress, city councillors, Corporation officials and members of the Miramar Borough Council were official guests. The Evening Post reported:

> *"A large number of the residents of Kilbirnie turned out to witness the historic event of the running of the first tramcar, and at the Mayor's invitation a carload of children were given a run along a portion of the section. The visitors from town were entertained at the Kilbirnie Hotel by Mr E T Taylor. Responding to the toast of his health, the Mayor said he felt sure the line was going to prove a success, for which the enterprise of the Hataitai Land Syndicate had to be thanked."*

The Hataitai side of the tunnel at the end of Waitoa Road

The representative from the land company replied by saying they hadn't acted out of philanthropy but with the hope of future benefits, and in fact the company wasted no time in promoting itself. Only two days later the Post reported that the Hataitai Land Company was opening up another block of sections and noted " completion of the connecting tunnel places what was the suburb of Hataitai on an equal footing with city residential property which is distant not more than 10 minutes by car from the GPO."

Initially tramcars ran every twenty minutes, and more frequently between 5 and 7pm. There was much discussion about where fare sections should be on the new route, with various residents' groups wanting a say. Those on the Mt Victoria side wanted a "penny section" fare to the Post Office, while those in Hataitai were concerned about consistency with the existing fare structure.

Conversion to Bus Tunnel

Wellington's trams were phased out in the 1960s, and in 1963 the tram tunnel was converted for use as a bus tunnel. The tram tracks, tram wire and two small water mains were taken out of the tunnel, and replaced with trolley bus wires, ducting for phone cables, electricity cables and a new 15-inch water main down the centre of the tunnel floor. This involved some ingenuity in the cramped space, as the Evening Post reported:

> *"lengths of water pipe are laid onto a number of paper bags full of dry sand, so the pipes will be high enough above the bottom of their trench for welders to join them together. When the whole length is welded together workmen will spike the paper bags. The sand will run onto the trench floor and the main will be lowered gently and evenly to its resting place."*

The first scheduled trolley bus service ran through the tunnel on Sunday 13 October 1963. Trolley buses and diesels still use the tunnel every day on the Miramar, Hataitai and Airport routes.

VECTOR CABLE TUNNEL

A joint venture between Downer and Seli (an Italian specialist tunnelling contractor) undertook the construction of a cable tunnel in Auckland for client Mercury Energy (which later became Vector) between 1997 and 2000. The Engineer for the contract was Tonkin & Taylor who undertook the detailed design and contract supervision.

The contract consisted of approximately 9kms of 3.0m diameter tunnelling with 3 primary shafts and several minor shafts providing network access to the city for power supply cabling. The tunnel follows an alignment from the Hobson Street substation in the CBD and then under public streets until it meets with the State Highway 1 southern motorway where it continues to the Grid Exit Point at Penrose.

The tunnel is located up to 80m below ground in the East Coast Bays Formation (ECBF) of the Waitemata group which are low strength (5-10MPa) interbedded siltstones and sandstones. The southern section of the project was overlain with basalt lava flows to a depth of approx 30m and required the Penrose shaft to use drill and blast methods for its initial sinking.

The project had three primary construction sites Hobson, Newmarket and Penrose with minor work carried out from Liverpool Street and Gilies Avenue.

The primary means of tunnel excavation were roadheader and TBM with the roadheader tunnelling being mainly undertaken from Hobson St and the TBM tunnelling from the Penrose site in Gavin Street.

The Hobson Street works were carried out using a roadheader due to the tight alignment necessary to negotiate the route under Hobson St, Mayoral Drive, Liverpool St and Symonds St. The drive terminated at a temporary chamber constructed to receive the TBM from Penrose and enable it to be dismantled underground.

Main tunnelling used an Alpine AM50 roadheader supported by 600mm gauge rolling stock consisting of Gemco 6T battery locomotives towing Hagglund self discharging muck cars. Muck was handled at the Hobson street shaft by a custom built elevating muck skip running in a lattice steel muck tower. The skip was lifted by an hydraulic winch which enabled the skip to tip into an open muck bin on the surface.

Temporary support for the tunnelling was provided by 2m steel resin anchored bolts supporting steel mesh. Wet shotcrete was additionally used as a temporary support where ground conditions required and also throughout the junction cavern developments. "W" strap reinforcement was also used in the Hobson St junction development prior to shotcreting, and steel sets were erected in the standard tunnel at fault locations.

Caverns were excavated using top heading and bench methods and the Liverpool development further split the top heading into two parallel side drifts all excavated with the AM50 roadheader.

Permanent lining of the standard tunnels used in-situ concrete lining with two travelling arch forms supplied from steel drop pipes delivering concrete at Hobson St and a purpose built facility adjacent to the Liverpool St site. Allied Concrete supplied all the temporary and permanent concrete and shotcrete for the project. Wet shotcrete additives included MBT SA160 accelerator and Novacon steel fibres that were sprayed through an Aliva wet shotcrete pump. Enlargements had permanent linings constructed from in-situ concrete in the invert and side walls with permanent steel fibre shotctrete for the crowns.

The TBM chamber was equipped with two overhead parallel monorails and four high capacity chain hoists to enable handling of the TBM components, and the chamber was finally lined with bespoke pre-cast concrete segments which were backfilled with flowable fill to infill the void between the segments and the temporary chamber lining.

The main Hobson St shaft was lined after completion of the main tunnelling using in-situ concrete placed behind a modified jump form (initially used at the Newmarket shaft) working 24hr cycles.

The Newmarket site located in the old Mercury Energy property in Nuffield Street, housed the project offices (both for Downer-Seli and Tonkin & Taylor) and the works from the Newmarket shaft

Newmarket tunnelling utilised a Mitsui Miike roadheader to develop the 3.0m finished diameter tunnels which led to the junction cavern situated under the Newmarket viaduct alignment.

Mucking of the temporary excavations used 6T Gemco battery locomotives hauling 600m gauge muck cars with sealed lift off tipping bodies. Shaft craneage was provided by hydraulic crawler crane.

Temporary tunnel support followed a similar arrangement to that of Hobson St and included 2m steel resin encapsulated bolts and steel mesh with steel fibre shotcrete in the junction cavern.

Permanent lining of the access tunnel was again by in-situ concrete using a travelling arch form. The junction cavern had the sidewalls and crown lined in permanent steel fibre shotcrete, with an in-situ concrete invert.

The Newmarket shaft provides the primary permanent man access to the tunnels together with the permanent surface installed ventilation extract facility and exhaust stack. The shaft was permanently lined with in-situ concrete using a jump form that was to be modified for later use at the other 2 main shafts. Again the lining construction followed a 24hr cycle.

The Newmarket junction cavern was constructed so as to allow the TBM driven from Penrose to pass through the cavern and recommence its drive to the final temporary dismantling chamber together with its permanent purpose of providing access to the tunnels in either direction.

The Penrose site was primarily concerned with the TBM drive which mainly followed the SH1 southern motorway alignment above that had horizontal geometry more suited to TBM operations.

The 60m deep shaft passed through a basalt lava flow which featured significant water inflows with temporary support comprising steel sets at 1m centres and timber lagging. Below the basalt, the shaft was excavated in ECBF and steel rock bolts with resin encapsulation were used together with steel fibre shotcrete as temporary support.

At the base of the shaft significant temporary development work was undertaken to enable the TBM muck handling equipment to be installed. Enlargements were prepared for the vertical muck conveyor and rail car "tippler" installation. The tippler supplied by Seli, lifted full muck cars from the tunnel trains and inverted them over the receiving hopper at the foot of the vertical conveyor. Muck was then carried in pockets on the belt up the shaft on to a discharge hopper over a surface conveyor adjacent to the shaft. The vertical conveyor was enclosed in galvanised ventilation ducting up the shaft to contain spillages from the belt during operation. The surface conveyor transported muck from the vertical conveyor to the apex of a covered muck shed where material was stockpiled for later disposal off-site.

Significant tunnelling work was undertaken using the Mitsui Miike roadheader to facilitate the assembly of the TBM and backup equipment underground as well as the development of the Penrose junction cavern. Temporary support of the starter tunnel used steel bolts with resin encapsulation and steel fibre shotcrete, but the Penrose junction cavern utilised full steel sets at 1m centres with timbering behind as temporary support.

The TBM was supplied by a purpose built in-house designed travelling gantry crane which delivered pre-cast segments and temporary equipment from the surface stockpile to the pit bottom. Pea gravel for bulk infilling behind the TBM pre-cast segments was transferred down the shaft by a gravity feed pipe. Personnel access in the shaft was facilitated by a temporary mast mounted man-access hoist.

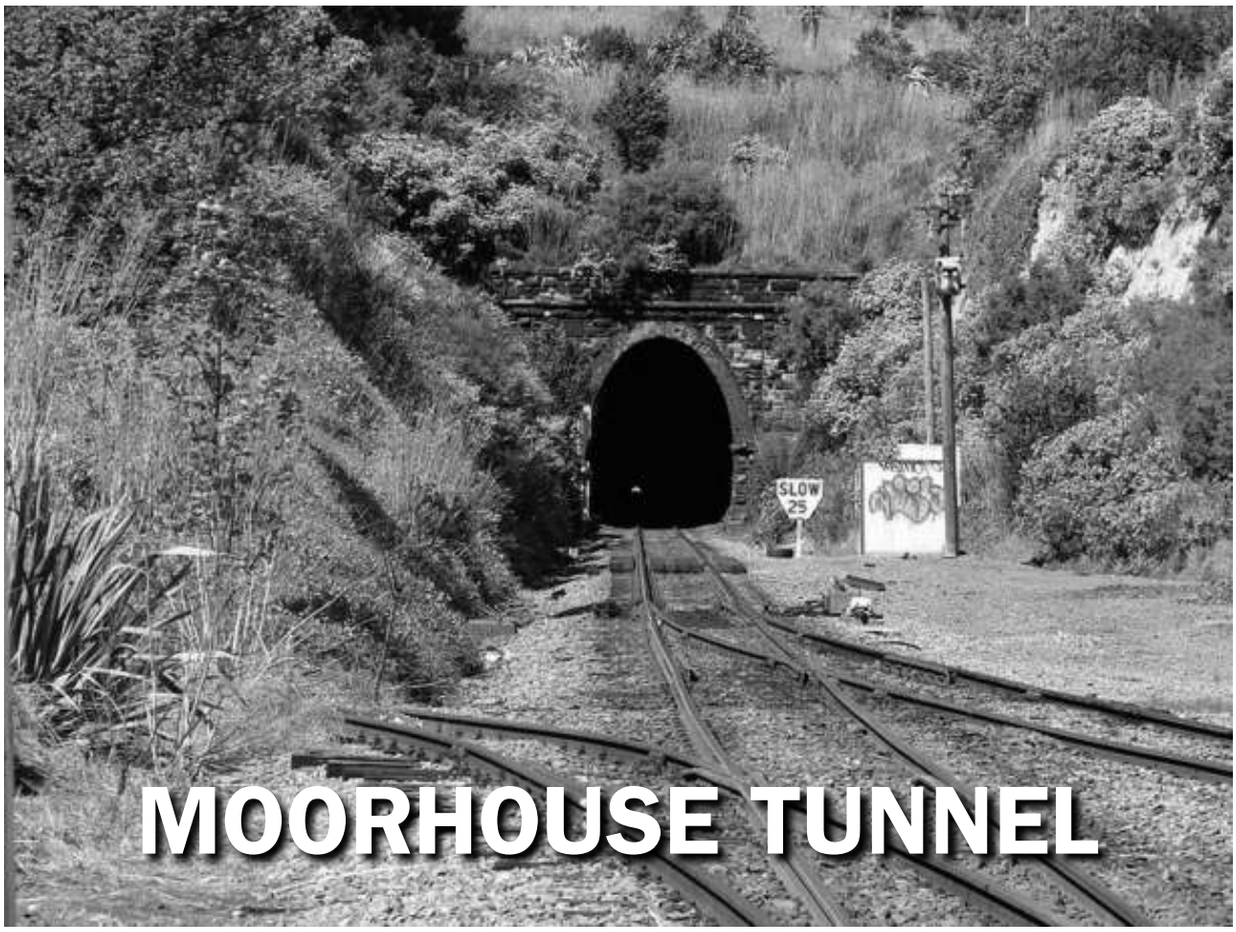
The TBM supplied by Seli was a Robbins 3.56m dia double shield machine, supported by diesel powered Schoma locomotives hauling muck and segment cars. A California switch was installed in the tunnel and the trains were driven onto the trailing backup of the TBM for unloading/loading operations. Additional Sig 8T battery locomotives were used for pit bottom shunting work. All TBM rolling stock was configured for 750mm gauge track.

Pre-cast concrete segments included steel fibres but were otherwise unreinforced, and were manufactured by Wilson pre-cast in Drury. Rings comprised six segments with an invert unit incorporating a pre-formed drain channel.

Permanent support to the TBM pre-cast lining was provided by pea gravel bulk infilling blown in place by compressed air from an Ocmer dry shotcrete machine. Voids in the pea gravel were subsequently grouted to complete the permanent lining. Hydrophilic gaskets installed on one face of the segment joints provided permanent waterproofing protection. Alignment & build adjustment of the pre-cast rings was achieved by the use of plastic packing strips sandwiched between the bolted rings.

Permanent lining of the Penrose junction used permanent steel fibre shotcrete for the sidewalls and crown together with an in-situ concrete invert. Permanent lining of the shaft used the jump form as for the other shafts on the project. The starter tunnel permanent lining used special invert pre-cast segments together with similar pre-cast units to the TBM reception chamber and were back-filled with flowable fill in a similar process.

Vector Tunnel Robbins TBM Breakthrough into TBM dismantling Chamber 19th January 2000.



MOORHOUSE TUNNEL

When the first settlers of the Canterbury Association arrived at Lyttelton they found an excellent harbour, but the steep and rugged hills surrounding it prevented easy access to their lands on the Canterbury Plains. A bridle path over the hill to Heathcote valley had been formed, but want of funds had delayed the completion of the proposed road to Summer.

The settlers could scale the hill on foot, (or on horseback when horses were available), but there was no road for vehicular traffic. The question of intercommunication between the port and the productive area thus early presented itself, and has continued to occupy the minds of some Canterbury residents ever since. At first goods were carried from the port in small boats round to Summer and up the Avon river, and later by larger vessels up: the Heathcote, but apart from the delay and uncertainty due to weather condition, there was a serious obstacle to navigation, the Sumner bar. One enterprising settler seeking to lessen the difficulties procured a small steamer, the Alma, to be used in towing the sailing craft over the bar, but the steamer was wrecked on the first trip to Sumner. The sailing craft continued to negotiate the bar when conditions were favourable.

It was obvious that the means of access were inadequate for any considerable business. The settlers had many discussions as to the possibilities of improvement, and later, on the establishment of responsible government, the discussions were continued in the Canterbury Provincial Council. It was decided to complete the Summer Road, but there was still doubt as to whether such completion was a satisfactory solution of the difficulty.

In 1856 a steamer service was established and the trading of sailing vessels up the Heathcote continued, but, with the increase of settlement, it was evident that improved transport for the growing trade had still to be provided. On 11th November, 1858, the provincial Council had resolved that a competent engineer be obtained from Britain to report as to the best means of communication between Lyttelton and Christ-Although doubts were expressed as to whether the province could afford what was recognised as a costly work for so small a community, public opinion had by this time settled that it was necessary to have a railway between the port and the city. There was the usual diversity of opinion as to thie best route. Finally the decision had to be made between a line to Sumner with tunnel under Evans Pass to Gollans Bay and the present direct line. A commission, consisting of Messrs. Fitzgerald, Cummins and Selfe, went to London and referred the question to Robert Stephenson, then a great Railway authority.

In 1859 a contract was arranged with a British firm Messrs. Smith and Knight of London. The terms of this contract were that the contractors should build the railway between Christchurch and Lyttelton in five years for the sum of £235,000, but the contract was to be terminable at any time within four months of the arrival of the contractors in the colony if:—(a) The Government could

not find the money; (b) The contractors found the work could not be done for the amount.

The representatives of the contractors arrived in New Zealand in December, 1859, and commenced preliminary investigation, but the first Railway Bill passed by the Provincial Council was disallowed by the Governor. On the expiry of the four months in April, 1860, the Provincial Government could not give a definite answer as to when the money would be available. The work was stopped while efforts were being made to obtain the authority of the General Government, but when in November the authority was at last obtained, the contractors declined to continue.

In spite of the difficulties the Canterbury people were not discouraged. Mr. W. H. Sefton Moorehouse, the then Superintendent, backed by the Provincial Council, continued to push matters forward. The Provincial Government took over the liabilities of the contractors and proceeded slowly with the trial headings of the tunnel, while inquiries were made for other contractors. Messrs. Smith and Knight in their work had encountered very hard material in the outer surfaces of the hill and the possibility of this continuing had influenced their decision not to continue the work. Mr. Moorehouse obtained the services of Doctor (afterwards Sir Julius) von Haast, a geologist who came to New Zealand with the Hochstetter Expedition, and was then in Nelson. As the result of his investigation he advised that the hill to be pierced was volcanic and that the hard outer crust would not continue throughout. His advice proved to be sound. Armed with this information the Provincial Government was able to negotiate and conclude a contract with Messrs. Geo. Holmes and Co. (Geo. Holmes and Edward Richardson) of Melbourne, to construct the railway (with the exception of the stations) in five years for the sum of £240,500 of which the tunnel was to cost £195,000.

The tender was accepted in May, 1861, and the first sod of the work was turned at Heathcote on 17th July of the same year. The work was completed and the line between Christchurch and Lyttelton opened in November, 1867. This determination in overcoming difficulties and pressing forward to the end in view is a fine example of the grit of the early settlers and worthy of remembrance by the present generation. In commemoration of the services of the Superintendent it was decided to name the tunnel The Moorehouse Tunnel.

Wrights Hill Fortress

Wrights Hill Fortress is a counter bombardment coastal artillery battery in the Karori suburb of Wellington, New Zealand.

It was built between 1942 and 1947 and is predominantly underground, with numerous tunnels linking the war shelters, gun emplacements, magazines, plotting rooms and engine room — which are, at some points, over 50 feet underground. The fort was intended to house three 9.2" Mk. XV guns, but only two guns were installed and the fort never saw action. After World War II was over, fort commanders fired both of the guns (Gun number one in 1946 and the second in 1947). The fall of the shot was observed in Cook Strait and these test firings (three rounds on each occasion) were deemed a success. In 1960, somewhat ironically, both of the guns were sold to the Japanese as scrap metal, the very nation Wrights Hill Fortress was constructed to defend Wellington against. The design of the fort is similar to the Stony Batter and Whangaparaoa 9.2" Mk. XV batteries, near Auckland.

Wrights Hill Fortress is currently in the hands of a preservation society and can be visited, by the public, on Waitangi Day, ANZAC Day, the Queen's birthday, and Labour Day. Tours may be booked, at other dates and times, — by prior arrangement. The Fortress is listed as a Category I Historic Place.

The New Zealand Tunnelling Company

Recruited in New Zealand in 1915, the men of the Tunnelling Company arrived in France in March 1916 under the command of 33-year-old regular soldier and Boer War veteran Major J.E. Duigan. The first New Zealanders to reach the Western Front, they were a so-called non-divisional unit — not part of the New Zealand Division, which arrived from Egypt the following month.

Most of the tunnellers were quarrymen, gold miners from Waihi and Karangahake, or labourers from the Railways and Public Works departments. Others were coal miners from the West Coast of the South Island, but these workers were generally discouraged from enlisting due to the essential nature of their industry. The hardbitten tunnellers gave Duigan some disciplinary headaches. He later grumbled that he had '17 ex-secretaries of Labour Unions in the Unit', as well as members of the 'Red' Federation of Labour. But with both the Allies and the Germans trying to tunnel under each other's lines to lay mines, their experience was invaluable. At first, they were involved in successful efforts to foil German mining — known as counter-mining operations — just to the north-east of Arras.

In November 1916 the tunnellers moved to Arras itself. Over the next five months the New Zealanders extended the two existing underground systems and created new tunnels. They constructed a complex system of galleries, subways, kitchens, headquarters and hospitals — facilities capable of housing 20,000 men. To assist orientation, the locations in one of the systems were all given New Zealand place names, from Bluff at one extremity to Russell at the other (another tunnel system had British place names). Godley Avenue, named after the New Zealand Expeditionary Force commander, Sir Alexander Godley, linked the locations. The New Zealanders also left graffiti on the walls, including a large 'Kia Ora' flanked by ferns.

The men of the Tunnelling Company were not the only New Zealand troops involved in this work. For two months they were assisted by the New Zealand Pioneer Battalion, many of whose members had been part of the Native (Maori) Contingent; this unit would eventually be renamed the New Zealand (Maori) Pioneer Battalion. Later, infantrymen from the New Zealand Division also helped out.

Christchurch cavern, Arras, 1917

This tunnel, leading to the Christchurch cavern beneath Arras, France, was built by the New Zealand Tunnelling Company during the First World War. It was one of a series of caverns and tunnels at Arras named after New Zealand cities and towns.

With a major Allied push planned for April 1917, the tunnellers shifted to a more offensive role early in the year. They tunnelled towards the enemy lines from inside the cavern system and laid three mines under German

trenches for detonation when the attack began. Tunnels were also driven to positions just short of the German trenches so that when the offensive was launched, troops could rapidly break through to the surface and man covering machine-guns, while others stormed the German positions. Following the attack on 9 April, the German line was pushed back 11 kilometres, and the Canadian Corps seized Vimy Ridge. As with most Western Front battles, this victory was achieved at a great cost in lives, with more than 12,000 Canadians being killed.

Following the April 1917 offensive, the tunnellers were deployed on a number of tasks in the vicinity of Arras. The underground system they helped create would prove vital to the Allies during the German offensive of 1918. The Tunnelling Company finally left the Arras area in July 1918, having suffered 41 deaths and 151 injuries during more than two years of service. The tunnels were closed after the Second World War and not rediscovered until 1990.

Writing in the Arras tunnels

These images show examples of writing on the walls of the Arras tunnel system.

- Top left — directions to the Wellington, Nelson and Blenheim tunnels (see map).
- Top right — during a visit to the Arras caverns in 1999, the Governor-General of New Zealand, Sir Michael Hardie Boys, laid this wreath beneath a large 'Kia Ora NZ' sign, flanked by fern leaves.
- Bottom — the name of a New Zealand soldier, Solomon Isaacs, carved in the chalk. Private Isaacs, one of three brothers who served in the New Zealand Expeditionary Force, was a Cook Islander who left New Zealand in February 1916. After serving with the Tunnelling

Company for several months, he joined the (Maori) Pioneer Battalion in February 1917. Nearly a year later he was sent, with other Cook Islanders, to Egypt, where he contracted pneumonia. He was repatriated to New Zealand, but his health remained poor, and he died in the Cook Islands in September 1923.

Map showing the tunnels at Arras

This map shows the location of the tunnels and caverns around Arras, where the New Zealand Tunnelling Company was active from 1916 to 1918. From Russell in the north to Bluff in the south, the parts of this tunnel system were identified by New Zealand place names. The town of Arras is just to the north-west of the area shown on this map.

The thin red and thick black lines at bottom right show the location of the British and German front trenches in 1916. 'Guernsey', at top right, was part of the main British tunnel system, which featured place names such as London, Carlisle, Liverpool and Glasgow.

Strongman mine explosion 1967

Nineteen men were killed when an explosion ripped through the Strongman Mine at Runanga just after 10 a.m. on 19th January 1967. An investigation concluded that safety regulations were not followed and that the shot was incorrectly fired.

Located near Greymouth, the Strongman mine (New Zealand's largest underground coal mine) had enjoyed an impeccable safety record since its opening in 1939. All that changed in January 1967 when an explosion sent a fireball through a section of the mine. There were 240 men working in the mine at the time. An even greater death toll was avoided because the fireball hit a wet patch in the tunnel near the explosion which caused it to slow and then extinguish itself.

Smoke and firedamp (methane gas produced by coal) made the task of searching for survivors and bodies particularly dangerous. When mixed with a certain level of air, firedamp becomes highly explosive and those involved in the rescue were at constant risk of another explosion. Fourteen bodies were recovered that day. It took another three weeks to retrieve two more bodies. The tunnel was sealed off before the last two could be recovered. A number of those involved in the rescue received the British Empire Medal for their bravery.

An inquiry into the disaster concluded that at least two mining regulations had been broken. The government was ordered to pay compensation to the families of the victims.

New Zealand's worst mining disaster remains the explosion at Brunnerton on the West Coast in 1896 in which 65 were killed.

Seddonville **State Mine**

In the 1890s all coal mines in New Zealand were run by private companies. The largest was the Westport Coal Company, a subsidiary of the Union Steam Ship Company, which was able to use its near-monopoly position to control coal production and keep prices high.

The 1896 Brunner mine disaster highlighted the poor safety record of the mining companies. Premier Richard Seddon decided that the best way to challenge the companies was to establish government-owned mines that would provide cheaper coal as well as setting higher safety standards and better working conditions for miners. The State Coal Mines Act 1901 authorised the Minister of Mines to open mines and carry out the business of coal mining.

The first state coal mine

The Seddonville and Point Elizabeth State Mines were designated at about the same time. Considerable work was needed at both localities before mining could start, but the Seddonville Mine produced coal in November 1903, beating Point Elizabeth by seven months.

Political issues were also important. The closure of the Mokihinui and Westport-Cardiff mines meant that there was almost no freight on the Seddonville railway line, and local residents petitioned Seddon to open a state mine there. Mines Department officials investigated the thick coal seam in Chasm Creek, and recommended opening the Seddonville State Mine in the hitherto unworked Cave area south of the abandoned Westport-Cardiff mine.

Before the mine could start producing coal, it was necessary to drive a tunnel, put in a rope haulage road and storage bins, and upgrade the railway siding. The first coal was produced in November 1903. It provided fuel for government departments, and the surplus was sold to coal merchants.

Mining problems

Although the output of the mine increased steadily, problems were soon apparent. Most of the coal was crushed and broken, with a high proportion of fine material that could not be sold. In 1908 a briquette works was started in Westport to use this fine coal, but it proved to be uneconomic.

More significantly, it soon became clear that the coal was not a continuous seam, but a series of 'pods' or 'lenses'. As the known areas of coal were gradually worked out there was a desperate search for new areas so that the mine could continue working. From 1909 to 1911 the area south of the mine was explored by drilling. Although a block of coal was found in the headwaters of Charming Creek, this did not seem large enough to support a mine.

Incline to Seddonville mine

The Seddonville State Mine had its largest annual output (more than 72,000 tonnes) in 1913, when 99 men and boys were employed. At the end of the year the manager reported: 'Having in view the near exhaustion of the mine ... the time is fast approaching when operations will have to be abandoned'. The mine closed in May 1914, and most of the miners left Seddonville.

Plan of Seddonville State Mine in 1912

Airport Link and Northern Busway tunnel

The network of tunnels under Brisbane's inner northern suburbs is continuing to grow with a major tunnelling breakthrough on the Airport Link in October 2010.

Thiess John Holland Project Director Gordon Ralph congratulated workers from the Northern Busway (Windsor to Kedron) project as a massive roadheader machine broke through in the 490 metre long Busway tunnel at Lutwyche. "This is an exciting time for the Airport Link projects with the network of tunnels beginning to connect across the northern suburbs," Mr Ralph said. "Seven kilometres of tunnels have been excavated by roadheader machines between Bowen Hills and Wooloowin to date."

This was the second 'breakthrough' in roadheader tunnels across the projects. In June 2010 roadheaders from the Bowen Hills and Truro Street, Windsor sites met in the northbound Airport Link tunnel. Later in the month, roadheaders from the Kedron and Wooloowin sites met in the eastbound Airport Link tunnel, and another breakthrough between Bowen Hills and Truro Street occured in the southbound alignment and the southbound on ramp at Kedron will reach the surface where construction will be completed with cut and cover tunnelling.

Tunnelling for this 490 metre long Busway tunnel began back in December 2009 with approximately 57,000 cubic metres of rock and soil excavated to date.

A total of 17 roadheaders are being used on the Airport Link projects, the largest number on any Australian project. Through a combination of roadheader, Tunnel Boring Machine (TBM) and cut and cover methods, the project is excavating approximately 15 kilometres of tunnels and ramps from Bowen Hills to Toombul.

Final assembly on Rocksy the TBM will be completed soon with the giant machine ready to recommence her journey in the eastbound tunnel from Toombul to Lutwyche, followed by her sister machine Sandy a few weeks later in the westbound tunnel.

Airport Link and the Northern Busway are due for completion in mid 2012, with the Airport Roundabout Upgrade on track to be fully open to traffic more than a year ahead of schedule.

When it opens in mid 2012, Airport Link will be the first major motorway connecting Brisbane city with the airport and northern suburbs. It will improve travel times in a city currently experiencing the worst peak hour traffic in the country providing six new lanes for drivers between Bowen Hills and Kedron and four new lanes between Kedron and Toombul.

Combined, Airport Link and the Northern Busway (Windsor to Kedron) are expected to reduce traffic on Lutwyche Road by up to 40%. The Northern Busway will provide fast, reliable public transport, catering for 47,000 trips per day in 2016 — more than five times the current number.

The $4.8 billion projects currently employ more than 3,600 people and are creating 12,000 direct and indirect jobs for Queensland.

TBM to be left underground

The constructors of the Airport Link have stated that parts of the tunnel-borer machines working on the tunnel will be left underground once the project is complete.

BrisConnections spokesman Charles MacDonald says the cost of extracting the cutter-heads from the front of the borers would have offset any savings. He says leaving them underground will also save time and avoid disruption at Lutwyche. "Building a shaft and a very large establishment on the surface ... as well as being a cost-expensive operation, would have an impact in the local community," he said. The 195-metre-long machines were specially designed and built for the project, to cut the tunnels from Toombul to Lutwyche.

Clem 7 Tunnel — support needed

The company that runs the Clem 7 tunnel, RiverCity Motorway has announced it needs the unanimous support of its 24 bankers to stave off going into receivership before the end of the year.

A shareholders' meeting was told the problem was that only around 30,000 vehicles use the toll tunnel each day, not the predicted 90,000 or so that were predicted before it opened.

Displays flashing on the electronic billboards above the Inner-City Bypass are trying to deliver more traffic to and from the tunnel.

In the meantime Queensland's coordinator-general has told the Brisbane City Council to alter its plans for a tunnel between Toowong and Kelvin Grove, in the city's north.

Residents had opposed plans for a control centre near the Mount Coot-tha Botanic Gardens, and the council has been told to find an alternative location.

Plans for a temporary car park at Toowong have also been knocked back, and a ventilation station will have to be buried to allow the future expansion of the gardens.

Completing Brisbane's inner ring road

The fourth tunnel in Lord Mayor Campbell Newman's TransApex plan could create the long-awaited ring-road system for Brisbane's inner city, with plans to link it to another tunnel planned between Toowong and Everton Park.

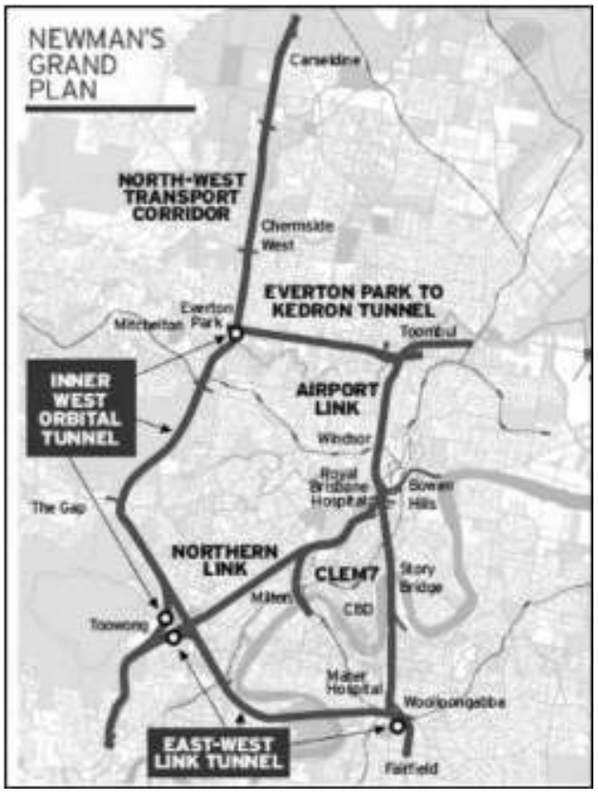
Deputy Mayor Graham Quirk said the 6km East-West Link, which will join the Pacific Motorway at Buranda and Toowong, may be linked to the State Government's proposed toll road between Toowong to Everton Park to improve traffic flows for the project.

Brisbane City Council will undertake a $1.4 million study for the East-West Link project over the next two years to review traffic demand for the tunnel — the final of the four tunnels proposed in the TransApex projects.

Cr Quirk said council would investigate a connection to the Toowong to Everton Park tunnel, known as the inner-west orbital link, which is undergoing a feasibility study as well as options to build the link separately.

''The inner-west orbital link combined with the East-West Link will provide a strong demand flow, but we want to look at them individually, and when this detailed work is done, it will have a couple of scenarios available,'' he said. ''But it is very early days and there has to be some research done.''

He said if the two projects were completed close to each other, it would improve the traffic flows using the East-West Link toll road. ''But as with the example of the Clem7 and Airport Link, when Airport Link comes on board that will increase the likely flow of traffic through Clem7,'' he said. ''So that's why we are looking at it as a stand-alone project and then what happens when you connect it to a further project.''



But inner-west orbital tunnel is not expected to be completed until 2031, despite being given a "priority project" tag by the State Government, while the East-West Link project was originally set to be built after 2026.

Coal rail tunnel plan shelved

A rail tunnel through the Liverpool Range has been shelved because miners in the region expect to extract a third less coal in the early years of operation.

The planned tunnel, at Ardglen, was one of six options being canvassed to increase rail capacity from the Gunnedah Basin. The CEO of the Australian Rail Track Corporation, David Marchant, says the miners have decided the nearly $1 billion cost of the tunnel is unaffordable while tonnages are low.

The New England independent MP, Tony Windsor, says he would not be ruling anything in or out just yet. However, he concedes if the mines planned by BHP-Billiton and Shenhua are not approved, the amount of coal coming out of the region will be lower. "Obviously there's a number of mines that have a question mark over them at the moment," he said.

"If those proposals didn't go ahead, in theory at least, obviously they would have an impact on the total tonnages that were being forecast in terms of the need for an upgrade of the Murrurundi Range."

Brisbane's Northern Link

The Transcity consortium has been named as the successful bidder to design, construct, maintain and operate the $1.8 billion Brisbane's Northern Link tunnel.

The tunnel will link Brisbane's western growth areas with the northern and eastern parts of the city.

Lord Mayor Campbell Newman said the appointment of Transcity — comprising Acciona, Ghella and Brisbane-based firm BMD Constructions — would deliver the best outcomes for Brisbane motorists and the local community.

"Northern Link will take pressure off Milton Road and Coronation Drive, providing a direct route between the Centenary Highway, the Western Freeway, the Inner City Bypass and the airport," Mr Newman said in a statement.

About 85 per cent of motorists using the tunnel were expected to bypass the CBD.

Construction on Northern Link will start in December and it is expected to open to traffic in late 2014.

Comprising two 12m-diameter parallel bores of around 4.3km in length, the Northern Link Tunnel will join up with Brisbane's Centenary Motorway and the Inner City Bypass. Each of the two tubes will have two lanes running at a depth of up to 40m below ground and will be excavated by a total of two tunnel boring machines. According to Acciona, the project will entail the removal of 2 million tonnes of rock and will require 1,200 concrete piles.

The project is part of the state of Queensland's infrastructure plan which aims to improve traffic and connections within the metropolitan area.

Some of Brisbane's Northern Link tunnel toll going to Legacy

Brisbane's Northern Link tunnel will be named Legacy Way to honour Australia's servicemen and women.

"One cent of every toll will go to Legacy, to go to the families of the diggers who have paid the supreme sacrifice for this nation," said. Lord Mayor Campbell Newman. "In the first five years, we estimate at least $600,000 will go to the families of the diggers."

Inside the Northern Link

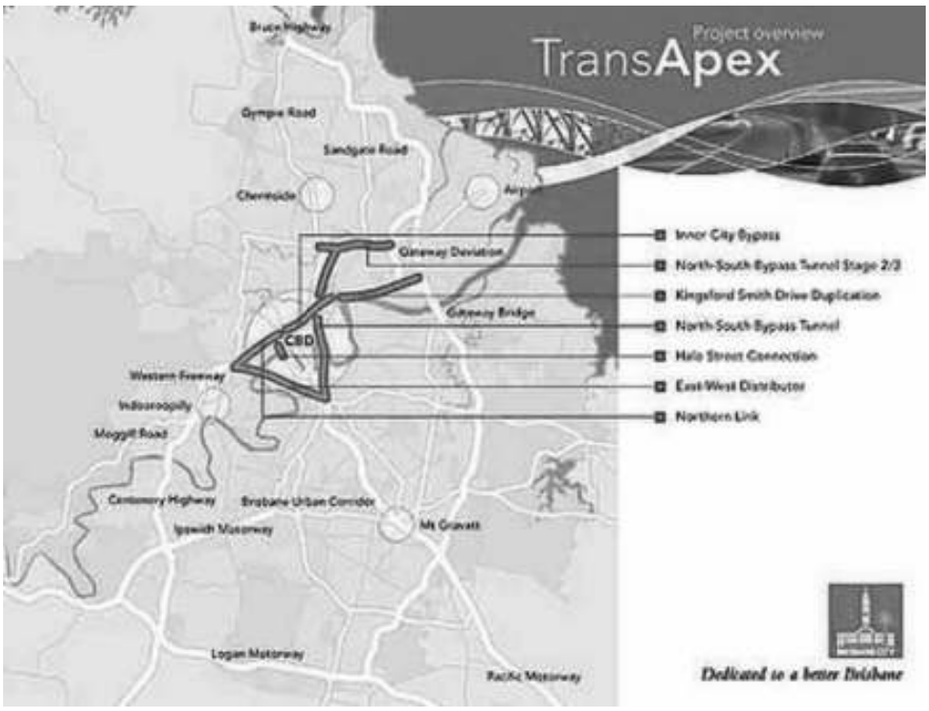
Traffic has been consistently growing in Brisbane by around two per cent a year or an extra 80,000 trips a day, but in the western suburbs that growth is even higher which puts immense pressure on roads like Milton Road and Coronation Drive.The projected time savings for the Northern Link are significant, with travel from the Centenary Bridge to the Inner City Bypass in the morning expected to be cut by up to 20 minutes.

The tunnel will have two lanes, each travelling in a different direction.

The proposed tunnel will run five kilometres from the Toowong Roundabout to the Inner City Bypass, providing two two-lane links from the Western Freeway to the Clem7 tunnel, to the Airport Link and ultimately through to the Brisbane Airport. It is planned to open in the second half of 2014.

One of the key issues to be decided is how can it be built under Toowong Cemetery without having an impact on the heritage-listed gravesites.

Friends of Toowong Cemetery have said the consortium set to construct the Northern Link toll tunnel must ensure they have a special fund to repair any damage to graves.



The cemetery is the final resting place of one prime minister, two Queensland governors, 13 premiers, 11 Labor leaders, and at least 15 mayors and the heritage-listed grave of Boer War veteran Trooper John Cobb, who died in 1901.

BMD Constructions, one of the Transcity joint venture partners, said they would brace any graves that needed protection. National engineering manager Dale Gilbert said they had already surveyed the graves and had processes in place to prevent any damage before starting tunnelling beneath graves.

"Part of how we are going to deliver the tunnel is 'how are we going to construct it, what are the vibrations, which graves are in what existing condition and identifying the ones that are a bit rickety because of the passing of time'," he said. "So there is proactive things we are going to do to do to some of those grave areas before we even start work to make sure we stabilise some of those existing graves.

M5 Cut and Cover Tunnel proposal

The Roads and Traffic Authority has delayed the creation of Wolli Creek Regional Park because it plans to build a "cut and cover" tunnel extending the M5 through the middle of it.

Documents from the RTA's M5 East corridor study indicate a proposed "cut and cover" tunnel and a proposed rock tunnel through the western end of the valley.

The RTA is a major landholder at the western end of the Wolli Creek valley, a ribbon of remnant rainforest that was promised protection as a regional park by the Carr government in 1998. Progress to consolidate the park has been slow, with only half the planned 50 hectares secured under the management of NSW National Parks.

A spokesman for the RTA said: "Some land near Wolli Creek may be required for a future M5 East expansion. However, planning for the M5 East expansion is at the early feasibility stage.

No decisions have been made on the location of any future tunnels." The spokesman said the RTA will soon carry out feasibility work in the Bexley Road and Wolli Creek area, and that consultation would follow.

Pacific Highway upgrade — Tintenbar to Ewingsdale

The Tintenbar to Ewingsdale upgrade will be about 17km long. It will start at the northern end of the Ballina bypass at Ross Lane and extend to the existing dual carriageway at Ewingsdale.

The existing highway currently bypasses the townships of Newrybar and Bangalow, and goes around St Helena Hill. The proposed upgrade would follow a similar alignment to the existing highway between Ross Lane and Bangalow, before diverting east at the existing Bangalow bypass and tunnelling underneath St Helena Hill. The upgraded highway would then follow a similar alignment to the existing highway north of St Helena Hill before tying-in with the existing Ewingsdale interchange. The tunnel would consist of two 1m diameter tubes of dual carriageway over a distance of 300m.

The NSW Minister for Planning approved the Pacific Highway Tintenbar to Ewingsdale upgrade on 29 January 2010. The Chief Executive of the NSW Roads and Traffic Authority (RTA) subsequently agreed to proceed with the construction and operation of the project subject to the conditions set by the Minister for Planning, the RTA's project priorities for upgrading the Pacific Highway and available funding.

Pedestrian tunnel for Barangaroo-Wynyard link

The NSW cabinet has agreed to spend $286 million to build a pedestrian tunnel to link Barangaroo with Wynyard station. At $1.4 million a metre, the cost of the 200-metre long nine metre wide walkway will be almost double that of the light rail extension to Dulwich Hill.

The chief executive of the Barangaroo Delivery Authority, John Tabart, said the high cost of the pedestrian link included the cost of buying some buildings and demolition works. While much of the walkway will be underground, sections will receive natural light and it will include a bridge across Sussex Street with lifts and escalators to connect to the site.

The pedestrian link was originally proposed as part of the planning for construction of the proposed metro network, with a station at Barangaroo. But when the government abandoned the metro earlier this year, it proceeded with the pedestrian walkway, which is regarded as providing essential access for most of 30,000 people expected to work at the site.

The City of Sydney believes that without the metro, existing public transport will be inadequate to service Barangaroo and it has been pressuring the government to guarantee funding for the pedestrian walkway, as most people travelling to the development will travel by train and bus to and from Wynyard.

"The pedestrian tunnel will be funded as part of the $50.2 billion Metropolitan Transport Plan," Transport Minister, John Robertson said.

City East Cable Tunnel

The Sydney CityGrid project is EnergyAustralia's plan for the Sydney CBD electricity network over the next decade and beyond. It involves constructing up to four new substations, replacing and upgrading the high voltage cables and constructing a new tunnel to link into the existing network of CBD cable tunnels.

A key part of the plans for the CBD is the new cable tunnel which will run from EnergyAustralia's property on the corner of Ann, Riley and Albion Streets to join the two existing CBD cable tunnels.

The first stage of the new City East Cable Tunnel (CECT) involves a 150 metre extension to the existing City South Cable Tunnel (CSCT) from the Riley Street site to Wade place where the existing tunnel finishes. This extension will be constructed using roadheader technology and work is scheduled to begin in the first half of 2011, subject to the planning approval process.

The second stage of the CECT will be a 3.2km tunnel from Riley Street into EnergyAustralia's new City North zone substation on the corner of Sussex and Erskine Streets in Sydney. This main section of the tunnel will be constructed using a tunnel boring machine.

The CECT will be the third dedicated transmission cable tunnel in the CBD and will link into the CSCT and the City West Cable Tunnel (CWCT) to form an electricity supply ring around the CBD.

Excavation is expected to take just over two years, followed by cable installation in the new tunnel over approximately 18 months.

New Sydney Harbour crossing

The NSW government would be remiss if it didn't provide a new Sydney Harbour crossing "into the future", Premier Kristina Keneally said responding to a report in that the state government plans to extend the $4.5 billion Western Express rail project with a second cross-harbour tunnel.

"We've never shied away from saying a second harbour (rail) crossing is something that was part of Sydney's future and in planning for our transport system of course we also have to plan for it to grow," Ms Keneally said. "It's always been assumed that there will be a second crossing over the harbour, but in planning for the Western Express line of course it's prudent to make provision for that into the future.

The Western Express, due to be finished in 2018, will take commuters from Sydney's west into the CBD on extra long express trains..

VICTORIAN DESALINATION PROJECT TUNNELS

Thiess Tunnelling, the latest division to join the Thiess brand, is undertaking the construction of the inlet and outlet tunnels and adit connections on the Victorian Desalination Project.

The tunnels connect the offshore risers to the Sea Water Lift Pump Station (SWLPS). The tunnel drives commenced from their portals located in the SWLPS boxcut, progressed out under the Williamson Beach sand dunes, and the Kilcunda – Harmers Haven Coastal Reserve to reach the marine risers. The tunnel alignment was determined on a number of critical elements, one of which was to ensure no long term impact to the surrounding pristine Gippsland environment, an objective which has been achieved.

The Tunnel Boring Machines (TBMs) selected to undertake the works are two identical Herrenknecht (HK) 4.71m diameter mixed shield TBMs. They were selected due to their reliable history and ability to excavate safely and efficiently through any type of material. HK Australia has provided technical support for the duration of the mobilisation and excavation. The TBMs were delivered a month apart, and for the bulk of the mobilisation phase, built simultaneously, in the tight confines of the boxcut.

Wonthaggi Maggie completed excavating the 1181m long inlet tunnel in late November 2010, a duration of 4 months. Wonthaggi Maggie's twin sister, Rocking Ruby, is due to complete the 1506m long outlet in late February 2011, a duration of 6 months. Both TBM back up gantries will be removed and the head and shields buried. The machines have excavated through a variety of different materials including clay, 2 MPa siltstone/mudstone, 10–20 MPa fine grained sandstone and 200 MPa basalt. There have been no consistent runs of any one material with bands of clay interspersed regularly along both drives. The cover to the tunnels ranges from 12 to 18m along both alignments, the cover at the riser locations is 18m with a maximum water depth of 23m.

The tunnels are lined with Universal segments with an internal diameter of 4m, the diameter which proved to be the most economically viable solution. The segment concrete mix is

The tunnels are lined with Universal segments with an internal diameter of 4m, the diameter which proved to be the most economically viable solution.

designed to meet the 100 year design life, with substantial durability issues realised due to the salinity of the water heading back through the outlet. Consequently, standard "off the shelf" mixes were unable to be utilised. However, after an extensive testing regime, a mix was attained that has exceeded all the design performance criteria.

The segments are transported to the TBM on Multi Service Vehicles (rubber tyred trucks), a first in a tunnel this size. The MSVs were selected ahead of traditional rolling stock for several reasons, but mainly because they negate the requirement for craneage on the surface and at pit bottom. The grade of the tunnels was another key factor. The slurry treatment plant and technical assistance is supplied by Piggott Shaft Drilling Ltd out of the UK. Tachibana supplied the back grout plant which is injected through the TBM tail skin. Both have operated well within contractual limits.

Work has commenced on the inlet adits which involves the installation of 250UC steel bracing rings within the existing tunnel, pre-grouting the rock mass, then excavation, temporary support and lining of the connections. The temporary support is provided by 200UC steel sets and shotcrete. The final liner within the adits is a 2.2m diameter GRP pipe.

The project team has a good mix of experience in the different construction techniques employed, which has resulted in no LTIs on the 460 working days of the tunnel project to date. This is testament to the attitude of the team through the development and implementation of safe work systems and by living the core values promoted by Thiess.

Northern Sewerage Project

The final tunnel has been completed as part of the $A650 million Northern Sewerage Project, located in Melbourne's northern suburbs.

The tunnel boring machine, Gemma, broke through on Fri, 22 October 2010 for the final section of tunnel to emerge at the Carr Street shaft in North Coburg. The project, which involved tunnelling up to 65 m below a busy part of Melbourne, is intended to create 13 km of new sewers under Melbourne's northern suburbs to meet the needs of a growing population.

Melbourne Water spokesman Phil Corluka said it had taken almost two-and-a-half years to excavate seven linked tunnels, which stretch from Reservoir to Coburg, Pascoe Vale and Essendon. "More than 90,000 new houses are expected to be built in the outer northern suburbs over the next 20 years and this project will make sure the sewerage system keeps pace with that growth," said Mr Corluka. Mr Corluka said the extra sewer capacity would also help to protect the health of Merri and Moonee Ponds creeks from the impact of sewage overflows that can occur after heavy rain.

There is still significant work to be completed on the five-year Northern Sewerage Project, including tunnel lining operations and connections to the existing sewer network. Construction on the project started in August 2007 and is expected to be completed by mid-2012.

More than 90,000 new houses are expected to be built in the outer northern suburbs over the next 20 years

Frankston Drainage Improvement Project

Tunnelling works to protect Frankston from floods during severe wet weather have been completed as part of the Frankston Drainage Improvement Project in Victoria.

The tunnel boring machine, Sandy, has spent the past year creating a 1.5 km underground drainage pipeline from Monash University to Kananook Creek.

Victorian Water Minister Tim Holding, who recently inspected the works, said "The tunnelling part of the project has now been completed and further work will now take place including tunnel connections to existing drainage lines."

Mr Holding said the $A41 million drainage project had been designed to significantly reduce the incidence of flooding in Frankston's central activity district. As a low lying area of Melbourne, Frankston is subject to serious flooding during severe wet weather and will soon be protected by Melbourne's longest stormwater tunnel.

Melbourne Water's Project Director Phil Corluka said future works as part of the project would involve the laying of drainage pipes under roads including Beach Street, Young Street and Fletcher Road in Frankston. The project is expected to be finished by the end of 2011.

The Frankston Drainage Improvement Project is being constructed by the Pipelines Alliance, a partnership between Melbourne Water, Fulton Hogan, Jaydo, and GHD.

Melbourne's WestLink

The State Government has outlined the route of the 3.5km road tunnel under Footscray Footscray tunnel as part of its WestLink freeway proposal which has been welcomed by the RACV. Under the plan, a 3.5km tunnel would stretch from the ports area to Paramount Rd, West Footscray, and the freeway would then continue to join the Western Ring Rd in Sunshine West.

Construction is not expected to start until at least 2013, and depends on Federal Government support for funding. No announcement has been made on whether the road would be tolled.

Roads Minister Tim Pallas said the link would be an alternative to the West Gate Bridge. "We're seeking Federal Government funding for WestLink because of its nation building capacity," Mr Pallas said. "This longer tunnel alignment was developed earlier this year to better protect the community and take more trucks off local streets."

Three proposals presented by the Linking Melbourne Authority are the "green option", an elevated road over rail crossings, the "blue option", mainly at surface level with overpasses at intersecting roads, and the "aqua option" with the longer tunnel.

Brimbank Council has made its submission on the proposed WestLink routes, selecting the version with a longer underground tunnel. In its submission, the council wrote that the green option placed the road closer to the Sunshine West residential area "which may have a negative impact on the residential amenity".

The green option requires 150 industrial properties to be acquired under the green option — the greatest number of any of the three options — and would have "the greatest impact on the natural environment" where it was to cross Kororoit Creek. While the blue option involveds the acquisition of about 45 industrial properties, the properties were much larger than in the green option. In the blue and aqua options, the impact on vegetation and on residential areas with regard to noise and visual amenity was less than with the green option.

Greens' plan for Fitzroy train tunnel

The Victorian Greens has suggested an ambitious $4.6 billion blueprint for public transport in Melbourne's eastern suburbs. It proposes to build a 10-kilometre train tunnel from Victoria Park to Parkville, with underground stations in Fitzroy and Carlton.

The transport plan, scraps the controversial $6 billion North-East Link freeway project in favour of a raft of public transport infrastructure projects.

Among the big-ticket projects the Greens list is a train to Doncaster, via Victoria Park. Estimated to cost $3.3 billion, the Greens plan to connect a proposed Doncaster railway line from Victoria Park to Parkville. This will run via a 10-kilometre tunnel through Collingwood, Fitzroy and Carlton. Victoria Park station would be rebuilt over the Eastern Freeway, while underground stations would be built at Fitzroy and Carlton.

Another five new stations would be built in Kew, Kew East, Bulleen and Doncaster Hill, where the train would terminate.

RMIT transport lecturer Paul Mees welcomed the plan. ''You could fund all these projects and more with the $6 billion from North-East Link, and that's exactly what we should be doing.''

Bendigo Hospital tunnel vision

Two tunnels under Arnold Street could link Bendigo's new acute hospital to an expanded cancer centre. Bendigo Health Precinct Community Advisory Committee chairman Don Erskine has suggested another option to linking the two sites, with an airport-like underground "pedestrian thoroughfare".

Friends of Bendigo Hospital want cancer services nearer to the acute hospital for quicker emergency treatment. Mr Erskine said one tunnel would be for hospital services and patients, and the other tunnel for the general public. He said most of the Friends of Bendigo Hospital's needs were met by the tunnel solution."The whole system will be linked by a major thoroughfare," he said.

Labor Member for Bendigo East Jacinta Allan said the committee would continue to look at patient transport between the two sites as another option. She said the tunnel would be completed within the budget.

Call for wallaby tunnel

Residents concerned about road kill are calling for an animal underpass at busy Burns Rd and Killeaton St in St Ives.

Bushcare volunteer Chris Robinson said two wallabies were run down by cars last weekend on this section of road and he was sick of seeing dead animals.

"Where Pymble Golf Course links with Cowan Creek is a wildlife corridor and we see lots of dead possums and wallabies," he said. "People drive blindly around and don't know what they hit or care what they hit."

Measures to prevent road kill could include a tunnel under the road or wire mesh fencing above, lowering the speed limit to 50km/h or putting up warning signs for motorists, he said.

The idea of a physical barrier is supported by members of Sydney Metropolitan Wildlife Services and WIRES, which says wallaby deaths in St Ives are increasing.

A council spokesman said physical barriers might not be effective because wallabies tended to move

around bushland without forming a specific habitat. "Unlike kangaroos, (they) don't congregate in large groups."

New signs would need approval from the RTA and if residents contacted council, the issue could be considered by its traffic committee. The Roads and Traffic Authority has already installed more than 200 animal crossings, including tunnels and bridges, on NSW highways.

Revival of Hobart city tunnel concept

A tunnel under the city could be a viable solution to Hobart's traffic problems, says Lord Mayor Rob Valentine. "The idea has come up and everyone says it will be too expensive but we have never seen actual costs," he said.

Alderman Damon Thomas last night revived the concept of retired local land surveyor Max Darcey for a 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.

But fellow aldermen at the council meeting said the city needed traffic solutions that did not involve building costly tunnels and watered down his motion to seek a staff report to examine the proposal.

An amendment by Alderman Marti Zucco called on the council to gauge state and federal government support to work in conjunction with the council on the report.

Ald Thomas said the tunnel would complement the recommendations of Jan Gehl, whose report on public spaces included new treatment for Macquarie and Davey streets including bus lanes and widened footpaths.

Ald Thomas said the tunnel could be developed and operated as a private-public partnership and supported by a toll.

WA Main Roads reject Tunnel idea

A proposed pedestrian tunnel under a section of the Coalfields Highway would not be possible due to a lack of funds, according to a Main Roads official. Main Roads south-west operations director Brett Belstead said that it was highly unlikely a pedestrian tunnel at the proposed site — under Coalfields Highway opposite Allanson School — would be given the green light.

At a recent Collie Shire Council meeting, Councillor John Piavanini moved the motion to approach Main Roads with a proposal to install a two- metre diameter Armco pedestrian tunnel. The motion was seconded by Cr Ian Miffling. Cr Piavanini said he believed in making the first cost the last cost. "I believe this option would be much safer to school children than a manned, lighted pedestrian crossing over the highway and once installed, would have minimal maintenance costs," he said.

The proposed site for the tunnel is currently undergoing works including clearing of the area. A contract variation would have to be put in place for the proposed underpass and therefore virtually impossible in the next two months, Mr Belstead said. "It would delay the current works being undertaken and there needs to be an identification of funds for the project. It has not happened at this stage and it is not feasible. There were concerns of notoriously poor social outcomes associated with underpasses, Mr Belstead said. "A pedestrian tunnel would ideally be located where you can see anyone who may be loitering inside. The site in Allanson would be unsuitable to meet this outcome as an underpass or tunnel would need to be excavated."

A construction contract is currently awaiting approval by Transport Minister Simon O'Brien for roadwork to commence on the Coalfields Highway.

The Tugun Bypass viewed from the northern interchange at Currumbin, QLD

Fire & Life Safety Design Considerations for the Tugun Bypass Tunnel

By Rob Bartlett, Senior Associate, Norman Disney & Young

The design fire size for a road tunnel has far-reaching implications on the design and costs associated with the tunnel structure and the fire and life safety systems. This article highlights the process of determining the design fire size for road tunnel projects, what the approach was previously, and how a risk review process, as used on the Tugun Bypass project, has significant benefits in obtaining a lower cost, tailored, fire and life safety solution which meets the broad requirements of the project stakeholders.

The design fire size for a tunnel has direct influence on the fire engineering analysis, the tunnel structural design (or its resistance to failure due to fire) and the design of the fire and life safety systems such as the tunnel ventilation, fire detection and fire protections systems.

Until recently, the maximum tunnel design fire size had traditionally been quantified in the design criteria of client briefs for road tunnel projects and was typically rated at 50MW. This was based on the fact that most tunnels within Australia were located in urban areas, the speed limit was generally limited to 80km/hr, and no dangerous goods were permitted to travel through. With the introduction of tunnel projects such as the Tugun Bypass project having parameters outside these usual norms, the standardisation of design criteria was no longer a valid option. An alternative approach was necessary which took into consideration the unique risks associated with each project.

Prior to the design of the Sydney Harbour tunnel in 1992, little consideration was given to fire and life safety design in Australian road tunnels. The design of the Sydney Harbour tunnel fire and life safety systems was based on limited US and PIARC data available at the time. In 2001, the Australasian Fire Authorities Council produced the *"Fire Safety Guidelines for Road Tunnels"* [1]. This document included relevant fire safety issues designed to provide information and guidelines to those Fire Brigades who may be involved in providing comment or requirements to road tunnel developers.

Tunnels up to 2006 were 'fire engineered' mainly for smoke management and egress provisions in line with the *designated* maximum design fire size. Since 2006, the risk

review process has enhanced the fire engineering process and considers the maximum credible fire scenarios unique to the project location and operating parameters.

In May this year I attended the *Tunnel Fire Safety & Ventilation Conference* in Graz, Austria, and following the conference was a guest at the PIARC Ventilation Working Group Meetings held at the Graz University of Technology. It was interesting to observe that of the 20 or more countries represented in the PIARC Ventilation Working Group, each had various local Authority requirements to follow either a performance based or prescriptive based approach to fire engineering. This group is currently working on a technical report titled, *"Design Fire Characteristics for Road Tunnels"*, in relation to determining the design fire size for road tunnel projects.

The aim of the report is to provide information and case studies to enable decision-making around the available options rather than advocating a performance based approach over a prescriptive based approach. There was a strong emphasis by the group on the importance of basing the report on solid research and the results from recently executed tunnel fire tests.

Fire testing of the smoke control system in the 2.4km long Kirchdorf S35 Tunnel (20km north of Graz, Austria), May 2010, just prior to opening.

To touch on the outcomes and conclusions from a number of full scale tunnel fire tests, we were able to see from the Runehamar [2], Memorial [3] and Reppafjord Tunnel fire tests [4] that *uncontrolled tunnel fires* (or those where no fire suppression is applied) result in poor visibility, very high temperatures and heat release rates, and significant impact on the integrity of the tunnel structure. These tests also showed that heat release rates in excess of 200MW could be generated from a fully developed non-dangerous goods fire.

By comparison, the results of the Benelux [5] and Piota Negra Tunnel fire tests [6] showed us that *controlled tunnel fires* — or fires where fire suppression is activated — result in cooler tunnel temperatures, limited visibility, lower heat release rates, and generally tenable conditions with the exception of visibility. The outcomes of the fire events in both the Sydney Harbour Tunnel and Melbourne City Link Tunnel reinforce these conclusions.

The Tugun Bypass project involved the design and construction of 7km of new motorway between Tweed Heads NSW and Currumbin QLD, including a 340m long tunnel. The objective of the project was to improve interstate travel through the Gold Coast and relieve the impact of traffic congestion on the local roads at Tugun. The project was designed and constructed under the PacificLink Alliance between Queensland Main Roads, SMEC and Abigroup. 'Best for project' thinking was encouraged by the Alliance at every level and across all aspects of the project. As a sub-consultant to SMEC, Norman Disney & Young was engaged for the design of the tunnel and motorway services. The project was very successful in opening to the public six months ahead of the contract schedule, whilst maintaining total costs below the original project budget.

The project was unique in that:

- the route was located across the NSW/QLD border, thereby doubling the number of stakeholder and interest groups involved
- part of it was constructed below the extension of the main runway of the Gold Coast Airport
- the posted speed limit was 100km/h, higher than most in the country, and
- most classes of dangerous goods (except explosives and flammable gases) were permitted to travel through.

The original project brief issued at the time of tender prescribed that the tunnel and services were to be designed to accommodate the effects of a maximum 100MW design fire. However, given the unique parameters of the project, the Scope of Works and Technical Criteria [7] issued at the time of contract award was amended to shift the responsibility for determination of the design fire size to the Alliance team.

The contract stated that, *"The mechanical ventilation and smoke control systems must be capable of fully functional continuous operation for the range of fire events up to and including a 50MW design fire as a minimum. The design fire must meet this minimum requirement and must address the requirements necessary for the nature of goods that will be permitted in the tunnel."*

The design team needed to be able to identify the full range of possible fire risks and threats, right from the minute to the unmanageable, and review their corresponding consequences in some sort of orderly fashion. A process was needed that clearly demonstrated the project team had exercised its duty of care to all stakeholders, and ultimately, to the public.

Given the large number of stakeholders involved, a Risk Review Workshop Process was decided upon as the vehicle to achieve this, and we acknowledge the good

The Tugun Bypass Tunnel constructed under the extension of the main runway of the Gold Coast Airport.

work done by Risk Consultant, Risk & Reliability Consultants (or R2A) in assisting in the facilitation of these workshops. With over 20 stakeholder groups involved from both sides of the state border, separate briefing sessions were held with each of the individual stakeholder groups, including:

- Design and construction team members
- Local Councils
- Road Authorities
- Airport Authorities
- Fire Brigades, including local commands
- Environmental departments, and
- Dangerous goods departments.

These briefings enabled each group to be given a plain english explanation of the project and its requirements, and sought specific feedback on the potential risks and fire and life safety issues important to that group. It also provided an opportunity for each group to raise issues of concern or opportunity outside of fire and life safety. Minutes were kept for each meeting and all issues raised were fed into a central risk register, and non-fire and life safety issues — such as environmental, safety and operational issues — were passed on to the relevant design group for consideration and inclusion in the design process.

A preliminary fire scenario and impact review matrix (or vulnerability matrix) was prepared for discussion with the stakeholders which listed out all of the foreseeable fire threats down one side, and the various entities which could be impacted by those threats across the top. A preliminary assessment was undertaken of the extent of consequences for each fire scenario, graded from no impact up to multiple fatalities [refer Table 1]. Of significant concern was the impact and magnitude of potential dangerous goods fires, and the effect of operating the deluge system on some types of dangerous goods which reacted with water.

The probability of each fire scenario was assessed, (whether "credible" or not), and whether systems or procedures could be put in place to mitigate the risks. For example, it was agreed that design to accommodate an aircraft misjudging the runway, colliding with the tunnel and bursting into flames was unwarranted, as the likelihood of such was extremely low.

Following the stakeholder briefing sessions, a workshop was held with all external stakeholders to test the credible fire scenarios identified and the proposed precautions. The sessions were also used to canvass the wider stakeholder group on whether there were any other credible fire scenarios needed to be considered by the design and construction team. Each of the fire scenarios identified were systematically reviewed in detail by the stakeholders, and profiling sheets were prepared which recorded the group's comments on the severity of each threat, along with the expected precautions or controls.

The outcomes from the stakeholder workshop were also used as input into the *Incident Management Plans* and to the *Safety Integrity Levels* (SIL) determination exercise for the Information, Communication & Technology Systems. Separate SIL Level workshops were conducted and attended by the design team, the technology providers, the proponent and the end users (operators) which looked at:

- the probability of occurrence of the scenario
- in situ control barriers to identify or avert a major tunnel fire event before it happens (such as normal traffic management, CCTV coverage or contact from the public at the early stage of a hazard), and
- the potential sequence of events in terms of decision making, response, and fire or control system activation times.

Table 1 — Sample Fire Scenario/Impact Review Matrix

	Public	Incident Response	Local Residents	Environment	Infrastructure
Motorcycle	X	X	–	–	–
Vehicle Fire	XX	XX	–	X	X
Bus Fire	XXX	XXX	–	X	XX
Non-Dangerous Goods Heavy Goods Vehicle Fire	XXX	XXX	–	XX	XX
Dangerous Goods — Flammable Gas Heavy Goods Vehicle Fire	XXX	XXX	XX	XX	XXX
Dangerous Goods — Toxic Gas Heavy Goods Vehicle Fire	XXX	XXX	X	X	–

XXX Potential extreme consequence event

XX Potential major consequence event

X Potential moderate consequence event

– No vulnerability detected

By looking at the combined effect of these items, the project team was able to logically establish that, to achieve the required levels of system reliability stated in the project brief, it was only the tunnel control and monitoring system which was required to be formally SIL rated, not the entire traffic management system or the fire protection system, which saved significant costs to the project.

The preliminary risk evaluation process initially established 35 tunnel fire threat scenarios. Following the individual stakeholder briefings and the fire issues risk workshop involving all stakeholders, 13 credible fire scenarios were determined. Similarities within these thirteen credible fire scenarios permitted detailed fire engineering analysis of seven credible fire scenarios.

Four controlled tunnel fire scenarios were analysed — with the deluge system activated — and yielded predicted fire heat release rates in the order of 7MW. Three (3) maximum test cases analysed the effect of a heavy goods vehicle entering the tunnel with a fully developed non-dangerous goods fire on board. These test cases yielded the maximum predicted fire size of 100MW.

Other outcomes of the risk review process identified:

- it is best to activate the deluge system on the fire early (even if the vehicle contains dangerous goods) to minimise the likelihood of the fire penetrating the packaging and exposing the dangerous goods load
- historically, the majority of fires have been limited to single vehicles, and were the result of a vehicle impact
- flammable liquid fuel fires are limited by the pool size which is dependent on the amount of fuel, the slope of the road and the capacity of the drainage system, and
- a high quality traffic management system and well thought out Incident Management Plans are vital to the prevention, detection and management of fire incident scenarios, and minimisation of their consequences.

In summary, the greatest fire and life safety risks associated with large infrastructure projects have low probability but extreme consequences if they occur. By undertaking a risk review process, all of the project stakeholders are brought together at the initial stages to quantify and categorise the risks. By harnessing the experience of the design and construction team and all of the relevant government, emergency services, environmental and specialist risk departments, it positions the expertise for dealing with these risks at the forefront.

The individual stakeholder briefings enable each group to understand the fire safety issues that may affect them, and enables their concerns to be put on the table and addressed early in the process. It is also a way of taking on board wider project issues, ideas, and suggestions which would not necessarily be captured in a wider forum because of time limitations.

The combined stakeholder workshops provide a vehicle for due diligence as each group comes to the workshop informed, and familiar with the objectives of the risk assessment process. All the necessary expertise is in the room to discuss the issues and address the concerns of others with factual responses. Ultimately, the risk review workshops are a vehicle for joint acceptance of the range of fire risk events, and to confirm the appropriateness of the precautions proposed to be put in place to mitigate those risks.

Smoke testing in the Tugun Bypass Tunnel, March 2008.

With agreement on credible tunnel fire scenarios, the fire engineering analysis and design of the tunnel fire and life safety and control systems can be tailored to the unique circumstances of a project. The result is cost-effective solutions at the desired level of safety and reliability acceptable to all stakeholders.

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NZ disaster 'a wake-up call' for Australian mining

Mining companies and unions in Australia say the Pike River tragedy has sent a wake-up call to the industry. It has been 14-years since the last multiple fatality in an Australian coal mine. In 1996 four miners died at the Gretley coal mine in the Hunter Valley. That was the last multiple fatality in an Australian coal mine.

The heads of some of Australia's biggest coal companies met in Sydney on 30th November to discuss mine safety. The claim in the industry in Australia is that improvements in technology and safety protocols have made the country's 44 underground coal mines among the safest in the world. But Bob Cameron, CEO and managing director of Centennial Coal, says the Pike River tragedy has been a cruel lesson for the industry.

Andrew Vickers, from the mining union CFMEU, says a tremor has been sent throughout the industry. The potential for accidents in any one of Australia's 44 underground coal mines is ever present.

Centennial Coal runs 10 of those mines. Mr Cameron, a former mining engineer, says it is a dangerous business. "Some coal mines, though not all, release methane as you mine the seam," he said. "Methane is an explosive gas in certain proportions with air and so we have to make sure that we dilute that methane as it's slowly released and it goes out with the ventilation air, out with the mine air and it therefore isn't hanging around and capable of being ignited."

The CFMEU's Andrew Vickers says the Australian mining industry can "be proud of its more recent safety record". Mr Vickers says the mining industry in Australia has learnt lessons from tragedies at Gretley, Moura, Appin and Box Flat. "We've demanded that the legislation be upgraded to put in place the safety precautions that we've learnt from the proper investigations of those disasters and the legislation now reflects the safety measures that are in place as a consequence of the lessons learnt from those disasters," he said.

Mr Cameron says mine safety is paramount to the industry. "Promulgating safety, it's got to be the first and foremost issue in all our minds, in every decision we make in our industry, in everything we do day by day," he said.

7th International Mines Rescue Competition

Appin Colliery, NSW, claimed victory at the 7th International Mines Rescue Competition, which was held from 8th–12th November 2010 at the Southern Mines Rescue Station, Woonona (Wollongong), NSW, Australia, with Chinese team, Zibo Mining Group runners up.

The competition, which was hosted by Coal Services Australia, was designed to test the skills of mines rescue competitors in a unique competition format. Teams representing India, China, the United States of America, Poland, Russia, Ukraine and Australia battled it out under grueling conditions to establish the ultimate victors.

A total of 16 mines rescue teams from seven countries competed in events including simulation of real events in an underground coal mine at Gujarat NRE, Russell Vale. Competitors were also exposed to the world's best practice virtual reality facilities for underground coal mining, which added a new layer of competition for the international mines rescue teams.

New underground operation for Mt Carlton

Conquest Mining has received a boost as a new high grade gold discovery at the Mount Carlton Project could add additional resources to the project, based near Townsville.

The results included one oustanding high grade intersection of 9.55m @ 11.6g/t Au, 25.3g/t Ag and 0.86% Cu from 148m, opening up the intriguing possibility of a high grade underground gold operation off the eastern side of the pit.

A secondary mineralised zone further down the hole also yielded 9.13m @ 2.14g/t Au, 15.1g/t Ag and 0.47% Cu from 172.87m, indicating the potential for further mineralisation at depth.

Jake Klein, executive chairman, remains very optimistic about the project saying, "These new results, identifying further high grade gold mineralisation peripheral to the V2 deposit, highlight the excellent potential for significant additional resources to be added to the Mount Carlton project, and underpinning our view of the prospectivity for new discoveries within our large regional tenement package."

Due to the positive results, further drilling has been planned to test the possible continuation of the gold mineralisation to the north east and at depth.

Argyle diamond mine goes underground

The managing director of Australia's largest diamond mine says the company will be doing all it can to train and keep its local workforce as the mine moves from an open-pit to underground operation.

The Argyle Diamond mine in the Kimberley region of Western Australia has spent the past 25 years as an open-pit project. By 2013, at a cost of $1.6 billion, the mine will move underground, which will extend diamond production beyond 2019.

Over the years the mine has reduced its need for fly-in-fly-out (FIFO) workers, having close to 80 per cent of its workforce living in the region, and 40 per cent of that are indigenous employees.

Managing director Kevin McLeish says maintaining a local workforce is a top priority. "The easy pathway would be to bring in skilled and ready people on a FIFO basis, but at Argyle we've changed our business model to be more of a local business and return more of the benefits from the diamond mine to the East Kimberley region," he says. "So we want to maintain our 80 per cent local and 40 per cent indigenous employment targets as we go into the underground, and what that means for us, is to make sure those local and indigenous people that are currently in our mining operation and who want to go underground, we'll try to do as much as we can to skill them up and give them a future in our new underground mine. That's our priority. We've worked very hard over the last five years to achieve the current 75 per cent local standing that we have and I wouldn't like to see that go backwards because we're moving underground."

Mt Morgans resource increase

The latest increase at Mount Morgans continues the growth in mineral resources, and brings the total increased ounces to 333 480 oz of gold, or 62%.

"The updated mineral resource underpins an increase in the average life-of-mine production profile to 50 000 oz/y, for six years from 2011/12. That is an increase from an average of 40 000 oz/y, for four years," said the MD Rick Watsford.

He noted that the increase in the mineral resource was the first step in delivering the growth plan to increase production to 100 000 oz/y, within five years, through extensional and brown field exploration.

"The highly successful low-cost and low-risk mineral resource definition programme at Mount Morgans supports the acceleration and expansion of our production," he added.

Watsford said in a statement that further increases to the mineral resources and ore reserves were expected at Mount Morgans.

"The 44% increase in mineral resource emphasises the excellent exposure of Range to a rising gold price through re-evaluation, discovery and development of near-mine extensional resources," he added.

Range River would undertake an updated openpit optimisation study on the new Millionaires mineral resource model, as well as an underground mining study to develop the economic mineable mineral inventory and ore reserve for Westralia/Millionaires.

A development plan and schedule, as well as an option study on alternatives for water disposal would also be developed.

These studies would be completed by the March quarter 2011.

Hera gold-base metals Project

Hera is located 100 kilometres south-east of Cobar and is hosted in Cobar Basin rocks.

YTC Resources acquired the high-grade Hera gold-base metals Project in June 2009, and has been pushing ahead to the complete a Definitive Feasibility Study (DFS) together with an aggressive exploration campaign both at Hera, and the associated Nymagee Copper Mine ore system, located 4.5km to the north. The DFS on Hera is to establish an underground mine producing gold, silver, lead, zinc and copper.

The Company holds a strong view that the Hera gold and base metals Project represents a robust mining proposition with major exploration upside well established by recent drilling results and by the +100 year histories of other mining operations in the Cobar district.

Drilling is also underway at the Nymagee Copper Mine, where following a detailed review of all historic work on the mine, YTC is targeting resources complementary to the Company's Hera Project, located only 4.5km to the south. The Nymagee Copper Mine is considered to have great potential to make a major addition to the proposed Hera Mine development.

Gold strike includes 4.2m at 164g/t

Bonanza style and high grade gold has been intersected in several holes in extension drilling at the Hera deposit.

Highlights include:

- 10.2 metres at 68.3g/t gold, 19g/t silver, 3.2% lead and 3.8% zinc from 520.2 metres, including 4.2 metres at 164g/t gold, 25.1g/t silver, 7.0% lead and 5.0% zinc.

Apart from emergence of a new gold-bearing lens east of the known Far West Lens, it is the high grade high grade base metal mineralisation, which is both exciting and striking, resembling a "Cobar Style" mineral system.

Hera has multiple lenses of high grade, sub-vertical gold and base metal mineralisation, with the central main lens representing the bulk of the deposit tonnes and extends for approximately 600 metres along strike.

ABB wins Cadia Contract

ABB Ltd. was recently awarded a contract in southeastern Australia to work on Cadia East gold and copper project of Newcrest Mining, a renowned gold company of the world.

The company will be providing electrical and automation systems for six underground mine conveyors of the largest underground mining project in Australia, expected to be completed in 2013.

Newcrest, which is the largest gold producer of Australia and ranks among the leading ten gold companies of the world, is said to produce gold at lowest cost. The Cadia East orebody possesses the largest amount of gold deposits in the world. Upon completion, the Cadia East mine project will become the biggest underground mine of Australia and is expected to operate for about 30 years.

ABB Ltd. will deliver its conveyor control system and its design, engineering and full electrical solution to the project in the first quarter of 2011. The comprehensive solutions of the company will be used to optimize energy efficiency and performance of all the mines at Cadia East.

Recently, the company also upgraded the distributed control system of the 1,200 megawatt Ilijan combined-cycle power plant in Batangas City, Philippines. The power plant is the largest power generation facility in the country and a part of Philippines' massive gas-to-power project. The plant, owned by KEILCO, started its operation in 2002.

The power and automation technologies provided by ABB Ltd. enable utility and industry customers to improve performance, while lowering environmental impact. The company has witnessed improving signs in late-cycle power, with some recent large contracts to be reported in 3Q10, including the largest transmission project awarded worth $700 million.

Based in Zurich, Switzerland, ABB Ltd. is a power and automation technology company. The company operates in five segments: Power Products and Power Systems supply products and complete Transmission and Distribution (T&D) solutions to utility and industrial customers.

Discrete Automation & Motion, Low-Voltage Products and Process Automation supply products, systems and solutions to customers across nearly all segments of the process and manufacturing industries, as well as specialist end markets, such as marine and utility. ABB Ltd operates in approximately 100 countries and structured its global organization into five regions, Europe, Americas, Asia, the Middle East, and Africa.

New excavation systems at North Parkes

The first of three new underground excavation systems is now ready for full scale performance verification trials at Northparkes' copper and gold mine in the Central West of New South Wales in 2012. Rio Tinto is developing new excavation systems as part of its Mine of the Future™ programme to significantly improve the construction and operation of underground mines.

Rio Tinto Head of Innovation John McGagh said the significant new investment offers the possibility for a step-change improvement over conventional drill and blast practices. Depending on rock conditions, this system should provide a capability to excavate at more than double the rate of conventional methods," Mr McGagh said. "For example, in a typical deep copper ore body, the rate of horizontal tunnelling could be as high as 10-13 metres a day using this new system. "Aker Wirth is one of three partners with whom Rio Tinto is working to develop new equipment and systems for the rapid construction of deep underground mines."

This new tunnelling boring system trial has been integrated into a previously announced $90 million pre-feasibility expansion study at Northparkes in August 2010 by Northparkes' joint venture partners Rio Tinto and Sumitomo Group companies. Mr McGagh said the trial will complete the final stage of performance verification of the new system.

The work is part of Rio Tinto's Mine of the Future programme, which aims to enable Rio Tinto to more effectively carry out exploration; more efficiently exploit resources; and to allow safer, faster and deeper underground operations whilst economically recovering valuable mineral resources from increasingly difficult deposits.

Aker Wirth Chief Executive Officer Christoph Kleuters said: "We are proud to have been selected by Rio Tinto as partner in this ambitious project. This system confirms Aker Wirth's commitment to maintain our position as technology leader in hard rock excavation for the underground mining and tunnelling industry." Mr McGagh said: "This is about The Mine of the Future programme going underground, as we promised we would at the start of 2010. This system incorporates continuous mechanical rock excavation that will not damage new tunnel walls, while still providing the ability to mechanically install ground support in parallel with tunnel advance. Importantly for Rio Tinto, it provides an opportunity to introduce fundamentally safer processes into the underground mining industry. "This announcement demonstrates Rio Tinto's ongoing commitment to exploiting step-change technology to deliver superior shareholder value whilst improving both safety and environmental performance."

The new tunnel boring system is expected to arrive in Australia in early 2012, and be operational with trials completed at Northparkes by the end of 2012. The system is 64 metres long, has a maximum boring diameter of six metres and has minimum tunnel dimensions of five metres by five metres. After the trial this technology is destined for use in other Rio Tinto underground mining operations internationally.

Barminco immerses itself in simulation

Major underground service provider Barminco has purchased its first UG360 equipment simulator from Immersive Technologies.

Barminco chief executive Neil Warburton said "this is a significant addition to our training capacity and we are looking forward to passing the benefits realised through this process onto our clients. Maintaining a high standard of training is vital for ensuring high safety standards across all of our projects"

The UG360 simulator was developed over three years and was specifically designed for training in underground mining conditions. According to Immersive, its display, feedback and measurement systems are designed to provide a trainee with effective skills transfer and a safe learning environment.

Immersive Technologies' chief executive Peter Salfinger said "in addition to partnering with Barminco, two underground mining customers in Australia have already acquired these simulators and have since incorporated them into their operator training programs. These include a leading copper miner in Northern Queensland and large nickel producer in Western Australia. Globally, Immersive has a number of additional UG360 simulator deals underway."

The first conversion kits to be made available for the UG360 are a range of Caterpillar underground trucks and load haul dumps units. Barminco's simulator will be commissioned in March 2011.

Resurrecting Russell Vale Coal Mine

Resurrecting a disused mine brings up a raft of challenges. Excavating coal from the mine's walls is only part of the difficulties faced in modern underground mining. Logistical constraints associated with transporting the material from the coal face to the surface –via an array of tunnels and shafts of various sizes — dramatically impacts upon a mine's overall production capacity.

In particular, the effectiveness of a conveyor system has a major impact on a project's material handling capability. On top of this, these bulk materials handling facilities need to be rugged enough to continuously operate in harsh underground conditions.

Gujarat NRE Coking Coal faced these problems when it was attempting to revive a closed down coal mine in New South Wales. When Gujarat acquired the disused mine at Russell Vale, near Wollongong, it looked to leverage the latest advances in longwall mining technology to change what was previously an uneconomically viable coal mine into a profitable one.

It found that it had to engineer a completely new conveyor system to handle the mine's forecast production levels. For this it approached Ellton Conveyors. The technology company was brought in to design, supply and install four conveyor systems for the mine.

To ensure the conveyors had the power to transport the materials, Ellton turned to SEW-Eurodrive for the drive unit assemblies. According to Ellton Group's managing director Mark Elliot the coal mine needed four new conveyor systems, each of which had to be powered by two drive units.

To "get the mine back into production, we found it was necessary to install a comprehensive set of modern material handling and transfer equipment," Elliot said. "The four conveyor systems will carry all of the mined coal from the face right through to the mine portal access at ground level."

Undertaking the task, SEW delivered eight identical drive units comprising of a motor, gear unit, fluid coupling and a drive base. A Toshiba 700kW motor and a Voith scoop controlled TPKL-R fluid coupling were free-issued by Ellton for each drive unit. SEW-Eurodrive also supplied its X-series foot-mounted bevel-helical gear units, rated at 156kNm, as well as purpose designing the drive bases on which to mount each completed drive assembly.

Kris Jaryn, SEW's industrial gears NSW product manager, said that it was necessary to closely match the gear unit to the motor and fluid coupling, and to customise this to meet Gujarat's Russell Vale application demands. "This project was unique due to the size of the equipment that is being used, and these are some of the largest gearboxes that SEW has supplied to the mining industry in Australia," Jaryn said.

Each gear unit was supplied with steel axial fans and rigid couplings, and was then custom fitted with a Hydrac oil-level sight-glass as well as an oil resistance temperature detector (RTD).

"The RTD allows the temperature inside the gearbox to be continually monitored," Jaryn explained. "This then enables a pre-programmed PLC to provide a warning signal if the gear units exceed a set temperature, which helps to ensure that they are always operating under optimal conditions."

The drive bases for the complete drive assembly were designed in Melbourne and manufactured just north of the mine, in Sydney. The drive units themselves, which weigh in at close to 14 tonnes each, were also assembled and laser aligned at the Sydney facility. The first two drive units have already been completed and delivered to the Gujarat NRE Number One Mine at the Russell Vale site, where Ellton proceeded to install them into the first of the site's new conveyor systems.

"This conveyor was installed and commissioned without a hitch, and has now been running smoothly for a while now," Jaryn said. An additional two complete drive assemblies have also been delivered in preparation for the next phase of infrastructure installation.

The remaining drive units and conveyors will be brought to the site over the coming months as the conveyor systems need to be installed in line with the development of the coal mine.

Elliot explained that they chose SEW as it provided a complete drive package solution, regardless of the size of the gear units required. "For this project we needed a solutions provider that could supply suitably sized drive units to operate the large conveyors needed to meet Gujarat's requirements.

"These are seriously large drives for an underground application; there can't be too many 700kW drive modules operating underground in Australia today," he added.

The commissioning of the first new conveyor paves the way for installation of the remaining systems, as the mine finalises its preparations for full production.

Remote control and automation used increasingly in mines' caving operations

Emphasis on work safety in underground mining operations is leading to increased usage of remote controlled equipment — particularly in mines employing caving methods.

Remote control and automation are playing an increasingly important role in caving operations. Automated ore chute control and remote controlled machines to bring down hang ups are just two examples. Truck drivers at Newcrest Mining's Telfer underground gold mine can now activate block cave chute doors from a safe location after the company adopted an innovative infrared remote control system from Remote Control Technologies (RCT).

Instead of chute operators standing on an overhead gantry near the trucks and activating the chutes via adjacent hard wired umbilical controls, they now tele-operate the chutes from the safety of their cabs. Control is through an infrared TX/RX system that obviated the need for radio signals and licences. The short-range system suffers no interference from mine radio or other signals.

RCT also incorporated a vision solution in the form of a Maxi Vision camera system featuring its 5555 underground Control Master® specification camera, mounted above the chutes for the truck operator vision.

"Infrared was seen as the only solution due to the relatively short-distance operating range," said RCT Mining Area Sales Manager in Western Australia, Phil Dean. There is no risk of false signals and interference from neighbouring chute systems. "The system has proved to be of great benefit. There is no need for operators to be exposed to heat, dust, fumes, poor ventilation, the possibility of mechanical failure of the chute system or complete a very repetitive process pressing a button to open and close the chute lip raise lower operation."

RCT has a similar system installed at Freeport Indonesia on four chutes. That system is also using radar to monitor the ore levels inside the ore passes.

Another development at Freeport Indonesia is a customised remote control solution developed for the giant Deep Ore Zone (DOZ) underground block cave, helping to solve safety and productivity issues that have long been associated with rock blockages in cave draw points.

RCT has helped develop a reliable remote controlled version of the Sandvik DC300 Commando drill. The hydraulic, self-propelled unit is also configured to deliver explosives into rock crevices to bring down hang ups. Optimally placed cameras are the eyes of an operator remote controlling the machine from a safe location. The Commando's functions are totally remote controlled.

RCT Area Sales Manager Nic Stone described the project as a "world first. It's a very important piece of gear because it does a high risk job — the machine goes into a large draw bell full of loose rock and places explosives — and takes a person out of that high-risk area," he explained. "There is no machine made to do that specifically, so we've modified and remote controlled a machine developed to do the job."

Stone said the hybrid drill/explosive delivery unit was not designed to be remote controlled and "we had to modify a lot of hydraulics. We re-engineered the hydraulics and modified a lot of the pilot systems ... to suit our remote control system and enable the machine to achieve the degree of movement the customer requires, under remote control."

RCT is also being successful in getting the safety benefits of remote control and automation accepted in countries not always thought of as leaders in technology. In Mali for example it has supplied and installed line-of-sight remote control systems for two Caterpillar LHDs in use at Randgold Resources' Loulo mine. More recently it has started breaking into China with its first installation going on to a Caterpillar R1700G loader at Sino Gold's White Mountain gold mine.

Phil Goode, Senior Business Development Manager comments: "these are our first remote control systems in China. Once customers see the safety benefits we are confident they will take many more."

Illawara Coal Defends vent Shaft

Illawara Coal has defended plans to build a mine ventilation shaft that pumps out 600 cubic metres of air a second near a public school.

The shaft will be located 600 metres from Douglas Primary School, but the company says it is necessary for their to ventilate the underground workings of Appin colliery.

"The air that's coming out of the shaft is basically the air that we breathe and it is indeed the air that the workforce that works underground breathes," says Illawarra coal spokesman John Brannon. He says issues regarding the shaft within the community have been dealt with, and they have assured the residents that the development will be safe.

"People raised those issues and what we did was address all the issues that people raised in our environmental assessment," he said. "There were no questions that people raised that we didn't address through our environmental assessment process."

The mine plans are being considered by the New South Wales Planning Department.

Myne Start Training Complex

Mastermyne is a Mining Services Business providing specialised services to the Australian Coal Sector. Mastermyne attributes much of its success to its people; having the ability to attract, train and develop teams to work on their operations that consistently deliver a safer and more productive outcome than their competitors is a significant differentiator for the Mastermyne operations. Underpinning Mastermyne's growth are people who are loyal, accountable and who are aligned with the operations culture that it's all "black and white".

Recently, like many in the mining sector, Mastermyne has seen a significant skill shortage looming large and posing a significant threat to the continued growth of its operations. Being a company that has based itself on finding solutions to complex issues Mastermyne established the first simulated training centre here in Mackay to train inexperienced labour in the basics of underground mining before taking up roles in its site operations.

The training centre is a unique facility that replicates the underground workings of a coal mine including actual size tunnels, operating conveyors and the equipment used underground. Trainees undergo a 4 week course which introduces them to all the necessary initial requirements of working underground. During the 4 weeks trainees are exposed to the safety tools used by Mastermyne on its sites and taught how and when to use these tools. Trainees are also introduced to the underground terminology and are then put to work undertaking the same tasks using the actual equipment they go on to use when on site.

Having already turned out its first crew of miners from the training centre the Mastermyne Management have been extremely impressed with the awareness, confidence and competence the trainees have acquired in the training centre. Mastermyne already has plans for similar centres throughout Qld and NSW.

George Fisher expansion gets green light

Xstrata Zinc's $A274 million expansion of its George Fisher zinc mine in Mount Isa has received the tick of approval from the Queensland government.

The George Fisher zinc mine expansion will result in an almost 30% ramp-up in production at the project from 2013.

Xstrata Zinc Australia chief operating officer Brian Hearne said the expansion of the underground mine was indicative of the strategic opportunities for growth within the group's assets. "George Fisher mine contains one of the largest zinc reserves in the world and the expansion project enables us to further tap its significant resource potential," Hearne said.

The George Fisher Mine expansion follows the approval of the $133 million Black Star Deeps open cut development to bring the total value of new mining projects in Mount Isa announced by Xstrata Zinc this year to $407 million. Both projects ensure the full utilisation of the zinc-lead concentrator capacity in Mount Isa which was raised to 8.0 million tonnes per annum in 2009.

The George Fisher mine expansion will increase the annual production rate from 3.5 million tonnes per annum to 4.5Mtpa and will create jobs for an additional 250 contractors during construction and 120 employees.

The project involves the development of a second hoisting shaft and associated infrastructure to service the northern area of the mine using large diameter raise boring technology.

It will include the installation of an underground crushing and ore handling facility and upgrades to power and air ventilation services. An existing shaft servicing the northern end of the mine will be lined and extended by 420 metres to a depth of 1140m.

The Xstrata executive committee approved the development late last month while the Queensland government's approval of a Mine Plan Variation for the project was received yesterday. The Mine Plan Variation was prepared based on a 14-month, $6.5 million feasibility study which found the project would cause minimal changes to the mine's current environmental conditions.

Hearne went on to say the expansion project had been encouraged by a 126% increase in zinc reserves from 33Mt when Xstrata acquired the operation in 2003 to 76Mt this year. "While the increased production rate will reduce the life of mine by five years to 21 years, the orebody remains open at depth to the north of the mine," he said. "The additional production capacity built into the expansion project and our ongoing exploration program will ensure GFM remains a key part of our long term strategy for Mount Isa."

Work will begin immediately on the 2.5-year expansion project with equipment mobilised to begin ventilation shaft works during November.

Jaguar Mine

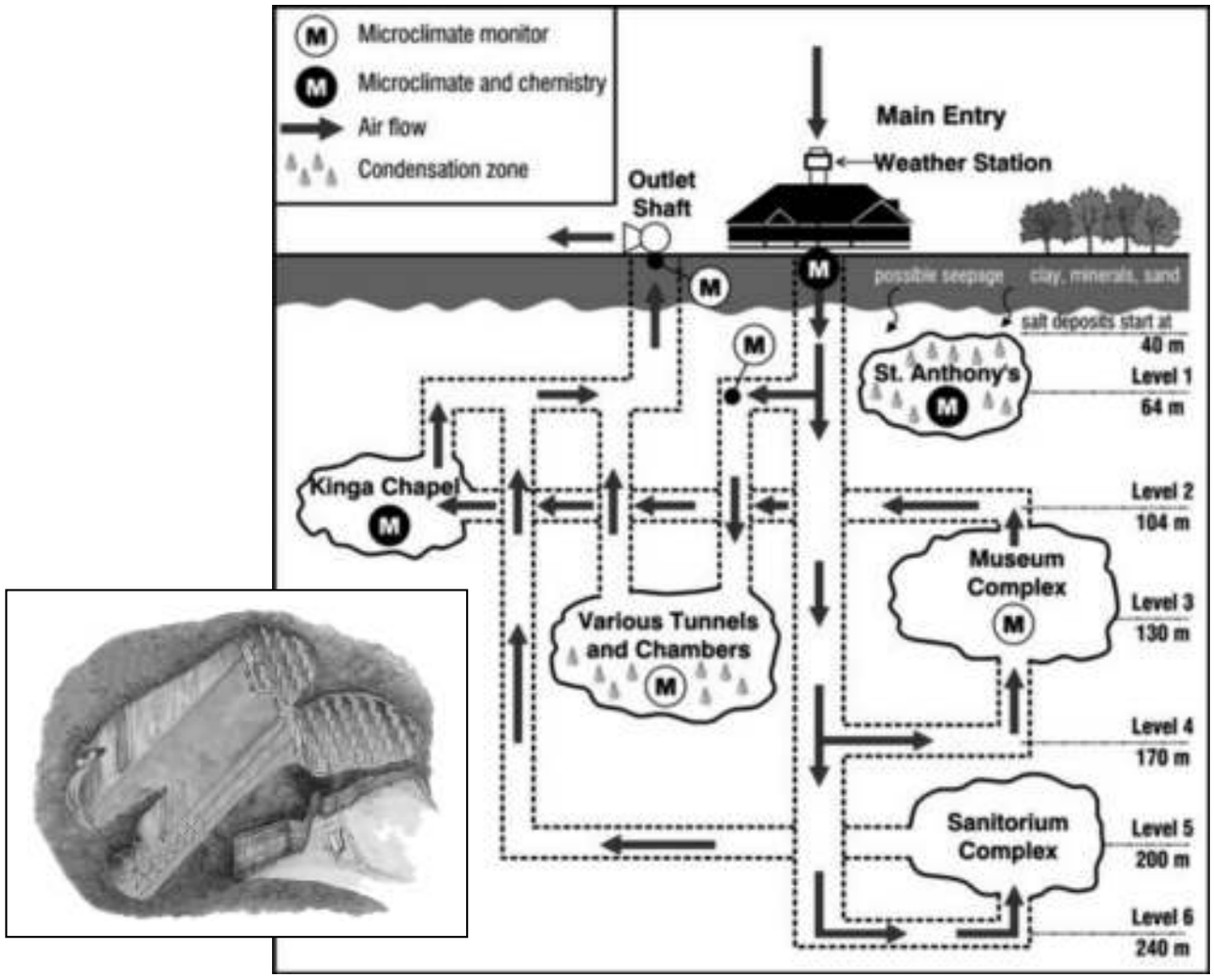
Base- and precious-metals developer Jabiru Metals has completed a definitive feasibility study on a A$10-million heavy-media separation (HMS) plant at its Jaguar multimetal operation, in Western Australia.

The Jaguar operation comprises an underground mine, a conventional grinding and flotation processing plant with a 450 000-t/y capacity. The project is prospective for copper, zinc, lead, silver and gold.

The company says that the recent project reserve remodelling, which saw the company acquire an additional tenure, has provided Jabiru with the opportunity to implement a "significant" value-adding capital programme with pretreatment of low-grade and stringer mineralisation through the use of HMS.

The modelling identified significant low-grade development ore and zones of stringer mineralisation, which could be upgraded through the HMS process, Jabiru said.

Metallurgical test work aimed at providing a preconcentration path for the stringer mineralisations has previously been completed, as well as test work to broaden the application of this technology to include low-grade stockpiles and development ore at both the Jaguar and Bentley underground mines.



Underground Research Facilities in Australia

Many techniques for preventing and/or extinguishing underground mine fires comes with a wide range of spatial and material techniques. These include the controlled "injection" of instant gel-foam barriers (operated via "an underground-based mobile gel preparation and injection system"), in order to block airflow through the mines, and the installation of ventilation control devices (VCDs), or rapidly deployed explosive barriers.

The "TestSafe Explosions Gallery" in Queensland, Australia is an experimental underground explosion lab and operates as a full-scale pressure test facility for ventilation control devices (VCDs).

This full-scale pressure test facility joins another Aussie site, called the Lake Lynn Experimental Mine (LLEM), a highly sophisticated underground and surface facility where large-scale explosion trials and mine fire research is conducted. The workings are located in a massive limestone deposit. Entries are sized to match those of commercial mines, making them authentic, full-scale test galleries. Movable bulkheads permit the setup of single-entry, triple-entry, and longwall face configurations for experiments. The underground test areas are amply instrumented and coupled to a remote control center at the surface. Research conducted at this facility includes large-scale gas and coal dust explosion studies, conveyor belt flammability trials, and evaluations of explosive materials and mine stoppings. In addition, diesel, ground control, and emergency response and rescue research is conducted here.

There is weather underground, then. In fact, it is interesting to note in this context that the famed Wieliczka Salt Mine outside Krakow, Poland, has its own weather station monitoring the atmospheric conditions underground. The station operates in tandem with a distributed network of microclimate sensors and a massive dehumidification system: Although the dehumidification system is not yet operating exactly as desired tuning' of the dehumidification system is planned and is expected to completely solve the mine's moisture problem.

Joy Equipment designed with Autodesk Enhances Mine Safety and Productivity

The JOY 14ED25 is used by mining companies to develop underground mine entries. Combining mining and bolting operations into a single machine helps promote zero harm in the underground mining environment by eliminating the need for two separate machines within the limited space of an underground entry. By utilizing the JOY 14ED25, mining companies can safely maximize both productivity and lower cost.

Digital Prototyping with Autodesk Inventor makes it easier for Joy engineers to design, visualize and simulate each JOY 14ED25 to meet customer specifications, while focusing on other important areas, such as ergonomics and better accessibility of serviceable parts. The resulting machines are easier to operate and maintain, while performing more reliably in harsh mining environments — all of which increases operator safety in multiple ways.

"Our machines are precisely tailored to meet the mining applications of each customer," said Chris Flynn, director of engineering systems at Joy. "We don't produce 'cookie-cutter' solutions. The powerful visualization capabilities in Autodesk Inventor help us share our vision of each customer's machine before we start to build it. We can arrive at the optimum solution virtually."

Historically, the development of underground mine entries has significantly slowed mining operations because two separate machines were required: a mining machine to cut the material and create a passageway, and a bolting machine to install large bolts that support the roof and side walls.

Joy relies on a comprehensive Digital Prototyping solution deployed by Autodesk Consulting and used by hundreds of engineers in the United States, United Kingdom, South Africa and Australia. Inventor software enables Joy engineers to digitally explore and test different ideas in 3D. In addition, Autodesk Vault Manufacturing software helps the company more effectively manage its engineering data — a critical business need when each machine contains from 3,000 to 7,000 discrete parts, and as many as 40,000 parts in total.

"Equipment manufacturers like Joy must balance pressure to get products to market faster while safely increasing production and reducing costs," said Robert "Buzz" Kross, senior vice president, Manufacturing Industry Group at Autodesk. "That is often a tall order, and we recognize the innovative engineering team behind this impressive continuous miner-bolter machine."

Tough conditions for tyres

Bridgestone Earthmover Tyres has launched a tyre application monitoring system for use in underground mines. The Underground Tonne kilometres per hour Monitor (UTM) system is designed to assist underground operators in improving safety and maximising tyre life across a wide range of applications and site conditions.

According to the company, increased demand for improved productivity, operating efficiency and safety in under¬ground mining has led to improvements to the equipment.

Many of the vehicles can carry larger loads at greater speed across increased in tramming distances. To meet these demands, purpose designed tyres have been developed to handle the increased loads and operating severity faced in underground operations. However, until now there has never been an operating data system capable of monitoring equipment activity and verifying the operational severity.

These are critical issues that ensure the correct tyre specification is selected for the application, the company said. The UTM is designed to measure the vehicle's speed, the distance travelled, the angle of ascent or descent using tilt sensors and the vehicle's side loading movement. In addition, a three-dimensional accelerometer captures the lateral, longitudinal and vertical forces to which the tyres are being subjected.

Over the past year, the unit was trialled in over 20 underground mines across Australia. According to the manufacturer, the system was fitted to a variety of equipment types, including underground boggers and haul trucks, providing operating data across a full range of primary production equipment.

The data will provide detailed information on the vehicle's operation and ways to improve areas of the site that are likely to increase tyre wear and damage.

The aim is to create a working environment which will generate both safer operating conditions and longer life for the tyres, the company said. "With the UTM, we can get an accurate idea of the tonne kilometres per hour and compare this with the performance of the tyres, because we can expect the tyres to perform to a known value," Bridgestone engineering manager Paul Comninos said. "If the tyre is under-performing compared to the known tonne kilometres per hour, we can see that the operation is actually quite severe on the tyre."

METHANE PREDICTION FOR UNDERGROUND MINING

When an underground coal mine ceases coal production, methane gas continues to flow into the underground workings through the process of desorption from residual coal within strata disturbed by mining activity.

For gassy mines this desorption process will continue for many years after closure and can resume when flooded mine workings are dewatered. The coal mine operator is therefore faced with potential long-term liabilities including explosion risks on the surface and possible dangers to the public as well as continuing greenhouse gas emissions.

After stopping the ventilation system, pumping mine water and sealing mine outlets to the atmosphere (shafts, inclines and service boreholes) gas release from goaf areas will continue until underground workings and macro-fractures are flooded.

In New South Wales and Queensland there are more than 50 underground gassy coal mines, which have ceased coal mining operations since after 1954. Responsible operators are now looking at ways to exploit methane from closed/sealed underground coal mines where practical to reduce environmental emissions, minimise public liability, to take advantage of an energy resource that would otherwise be wasted, provide some continuing local employment and to gain added value from the mine before total abandonment.

Whereas various methods for predicting gas emissions in working mines are available and in regular use, no complete methodology has been established for predicting the decay of emissions once coal production ceases and the coal mine is no longer operating.

However, extensive studies on gas emission from sealed goaves and abandoned coal mines have been undertaken by Lunagas using data predominantly from NSW and Queensland underground coal mines complemented by additional data from UK, Poland, Czech Republic, USA and Japan. Thus, a method for forecasting long-term gas emission decay was developed for use by specialist industry practitioners in which predicted and measured data showed good correspondence.

The future development of coal mine methane utilisation from coal mines goaf in Australia will depend on the availability of suitable sites and their proximity to a customer. Viability will also depend on the ability to predict both the quantity and decline rate of coal mine methane from those mines, to meet customer requirements whilst at the same time generating a profit for the operator.

The method for estimating abandoned coal mine and goaf area methane potential is applicable to both dry and flooded mines and also takes into account coal mine methane utilisation options.

The national and local energy market for gas and electricity use is continually changing and schemes must be flexible to accommodate these changes while maintaining commercial viability and customer satisfaction.

It is therefore in the interests of coal mine operators to monitor and gather gas emission data from goaf areas to accurately quantify current emissions and to predict future emission for exploitation potential assessment.

Lunagas has developed a practical and scientifically-based prediction tool for assessing the methane production potential of underground coal mines goaf areas ranging in size from a single panel to whole-of-mine. The Coal Mine Goaf Gas Predictor (CMGGP) is simulation software for predicting the decline rate of gas make and calculating the gas reservoir capacity of coal mine goaves.

The method for estimating abandoned coal mine and goaf area methane potential is applicable to both dry and flooded mines and also takes into account coal mine methane utilisation options.

The software comprises three main sections. The first is the "coal mine parameters," in which data is entered to facilitate calculation of the decline curves for both dry and wet mines.

The second is "gas reservoir characteristics," which allows entry of stratigraphical data for calculating the available gas reservoir. The third is "methane decline curves and gas reservoir," charts (decline curves) showing the results of calculations made based on data in the above two sections.

The software will run on a PC with windows XP or vista operating system and can be used by individual specialists, coal mines and other institutions involved in coal mine closure, coal mine methane utilisation and greenhouse gas emissions reduction.

Energy companies and city councils may find the software useful for determining methods to better utilise the majority of coal mine gases in order to protect the environment from harmful gasses.

** This is an edited version of a conference paper, 'Coal mine goaf gas predictor (CMGGP)', originally published by Les Lunarzewski for AusIMM Illawarra Branch's 2010 Underground Coal Operators' Conference.*

Upper Kotmale Hydro Power

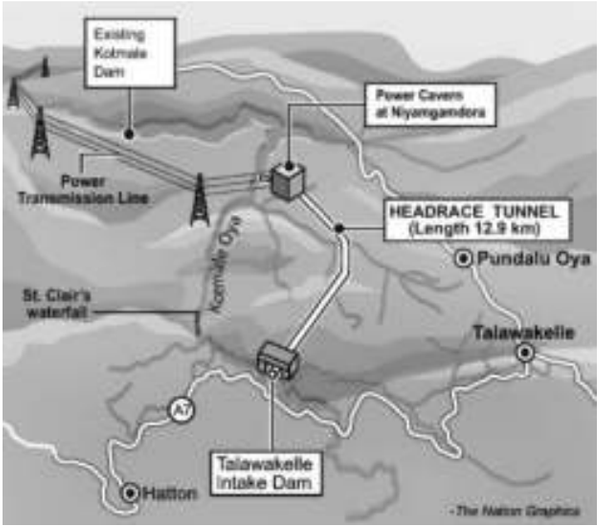
The longest underground tunnel (13km) built in Sri Lanka was declared open in October 2010 and more than 10,000 people flocked to Upper Kotmale Hydro Power (UKHP) project site to experience this novel development activities taking place in the country.

The UKHP is the last mega scale hydropower plant in Sri Lanka with an installed capacity of 150MW (consisting of two 75MW units) and it will produce 409GWh per year. All the other hydropower projects will be of less than 40MW capacity.

According to the project manager R S W Wagarachchi, "The tunnel was built in four phases where the dam/weir and the power station were connected through access tunnels coming from four directions which ultimately connected as one. We used laser guides for accuracy as the tunnel starts bending in the middle even though it is almost horizontal at the beginning. A 4-km long stretch was completed by January 2010 as the first phase of the tunnel," he said.

Wagarachchi said that they had achieved 80% progress in constructing the 35-metre high weir which is 157 metres in length.

"Water coming through the tunnel will fall into two turbines — each 75MW units through another angle tower of 463 metres' long. The water collected underground will go back to the existing Kotmale power plant through another 450-metre long tunnel built across Kotmale Oya," he explained. He asserted that precautionary measures also have been taken to avoid any damage to the underground tunnel in an emergency.



"For instance if the operations in the underground power plant stopped for some reason it will cause a surge by sending back the water flow through the tunnel. This will damage the tunnel. To avoid this, we have built a surge tank/well which again is a vertical tunnel.

The Japanese-funded UKHP project is being constructed under five contracts where the main contractor has to be a Japanese company while all the sub-contractors are local.

"This was according to the funding agreement or the government's soft loan agreement. Our main funding agency is JICA which provided 33,265 million Japanese Yen and the rest of Rs 5,931 m was provided by the Ceylon Electricity Board."

According to Wagarachchi, some 2,250 are employed in the project directly. Out of this 2,100 are locals while 150 are expatriates. "There are also about 150 local engineers and 60 foreign engineers mainly from Japan, Nepal and

Malaysia," he added. The project also involves lots of community and infrastructure development which was mainly aimed at resettling the affected people. Under this, some 495 families have been identified and each family was given a permanent house of not less than 620 square feet.

"Those who lived in a bigger floor area were also given a house with bigger floor area and all those who are resettled will be living in a house bigger than the previous. We carried a survey in 2002 and identified 495 families. Out of these 430 houses have been already completed and resettled while another six establishments also have been completed. The progress of resettlement is 92 per cent," he added.

He said new houses were being given to each and every affected family.

They were being provided with all the infrastructure facilities such as water, electricity and sanitation.

In addition, the resettlers are provided with all other common amenities including medical centres, community halls and religious places like churches and kovils.

History and project location

The Upper Kotmale Hydropower Project was conceived with the preparation of a master plan for hydroelectric development in the Mahaweli Basin in 1968.

The concepts in the master plan were further studied in 1985-1987 when the Japanese government funded a feasibility study to examine hydropower options in the Upper reaches of Kotmale Oya.

Five sites and eight alternative development schemes were examined in the feasibility study and the report concluded that the development of two sites were technically and economically feasible.

The two sites were a reservoir type development at Caledonia and a run of river project at Talawakelle. The project at Caledonia involved the displacement of 2,700 families and inundation of large area of tea land.

The Japanese Government then provided further funding for the Engineering Service Study, which included the review of the feasibility study, selection of the optimal development plan, the development of the detailed design

UPPER KOTMALE - TIMELINE	
1967 - 1968	Mahaweli Master Plan identified Upper Kotmale Hydro Power Potential , UNDP FAO Study
1985 - 1987	Feasibility studies
1993 - 1995	Engineering Service study , Environmental Impact Study of Upper Kotmale Hydro Power Project
1995 - 1998	Studies of alternatives done and appeal for Environmental Clearance.
1998 July	Environmental Clearance Granted under the National Environmental Act.
2000 March	The final Environmental Clearance granted subsequent to a settlement of an appeal made in the Court of Appeal by an Environmental NGO.
2002 Mar 13	Cabinet of Ministers approved the loan to finance the UKHP Project.
2002 Mar 28	Loan agreement between the Governments of Japan and Sri Lanka was signed.
2002 July 10	Report of the Inter-Ministerial Committee: Upper Kotmale Hydro Power Project. Submitted its report to the government recommending the implementation of the Project with recommendations to mitigate the environmental impacts.
2002 Aug 21	Cabinet of Ministers approved the project with the Environmental Mitigation Measures to be published under the National Environmental Act.
2003 Apr 10	Publication of the Gazette Extraordinary bearing number 1283/19 - National Environmental (Upper Kotmale Hydro Hydro-Power Project - Monitoring) Regulations No.1 of 2003.
2003 Oct 15	Cabinet of Ministers approved the appointment of Consultants for the implementation of the project.
2003 Nov 5	Consultants were appointed to the project, they commenced the work on November 16, 2003.
2004 July 21	Approval of the Cabinet of Ministers for the Strategic Plan to Strengthen the Ceylon Electricity Board in which the Implementation of UKHP was given priority.
2005 Apr 7	Cabinet of Ministers has taken a decision to proceed with the project limiting its scope only on St.Clairs waterfall.
2005 July 15	Lot-1 Preparatory works contract was awarded to M/S Maeda Corporation of Japan
2005 July 27	Lot-1 Contract agreement was signed between the Ceylon Electricity Board and M/S Maeda Corporation Japan.
2006 Dec 06	Lot-2 Contract agreement was signed between the Ceylon Electricity Board and M/S Maeda Nishimatsu Joint Venture (MNJV) , Japan
2007 Nov 21	Lot-3 Contract agreement was signed between Ceylon Electricity Board and M/S Kurimoto Ltd, Japan.
2008 June 20	Lot-4 Contract agreement was signed between Ceylon Electricity Board and M/S Mitsubishi Corporation, Japan.
2009 Oct 06	Lot-5 Contract agreement was signed between Ceylon Electricity Board and M/S Kinden Corporation, Japan.
2010 Aug 17	Tunnel excavation was completed

and preparation of Tender Documents and an Environmental Impact Assessment Report (EIAR). The EIAR was issued in September 1994.

The final design report was completed in March 1995. The Environmental Impact Assessment identified key issues associated with the UKHP as, impacts on water fall aesthetics due to stream flow reductions, social impacts due to resettlement of affected people, possible effects on ground water due to tunnelling, impacts due to de-watering of streams on downstream water uses and impacts on bio-diversity.

Further detailed studies on alternatives were completed in 1996 and the Secretary of the Ministry of Forestry and Environment granted approval for the project under the National Environment Act in July 1998 subject to strict adoption of proposed mitigatory measures to minimise possible environmental impacts, which included the development of a watershed management plan, maintenance of daytime flows over the waterfalls, monitoring of groundwater levels, an assessment of biodiversity, management of tunnel waste and a resettlement programme.

This decision was challenged in the Court of Appeal in October 1998. The secretary to the Ministry of Forestry and Environment gave the final order in March 2000, subsequent to the settlement of the appeal.

The government secured financial support in March 2002 from the Japanese government to implement the project, signing of Loan Agreement SL-P74 in March 28, 2002.

The decision of the Secretary in March 2000 was further strengthened with the gazetting of the National Environmental (Upper Kotmale Hydro-power Project — Monitoring) Regulations No. 1, 2003.

The UKHP is located in the southern highlands of the country and is part of the Nuwara Eliya administrative district.

The project area covers some 540km2 of the upstream catchment of the Kotmale Oya, a tributary of the Mahaweli River.

The infrastructure for the project is confined to a much smaller area and is contained in a triangle with the A5 Kandy-Nuwara Eliya Road forming the eastern side, the A7 Hatton-Nuwara Eliya Road the southern side and a line running north-south from the existing Kotmale power station to the Devon Oya completing the western side.

The land of the project area is mountainous with a striking landscape of deep river valleys running beneath high cliffs and escarpments.

The project area is predominantly rural in character with the majority of the population living in small rural communities or on tea plantations.

The dam site is located on the edge of the town of Talawakelle which has a population of around 3750. The only other town of any size is Pundal Oya which has a population of 2,000.

Thu Thiem tunnel links up

Nhan Dan Online — A ceremony to celebrate the linking of the final sections of the Thu Thiem tunnel under the Sai Gon river was held in Ho Chi Minh City yesterday.

The tunnel is the most important part of the East-West Highway Project. It is the longest tunnel in Southeast Asia with the length of 1.49 kilometres.

The 33.3 metre wide tunnel has six lanes, and is capable of carrying 45,000 cars and 15,000 motorbikes everyday, at speeds up to 60 kilometres per hour.

Work on the tunnel started in February 2005. From March until June, the tunnel's four 110,000 tonne sections were towed from the casting station in Nhon Trach district of Dong Nai province, to the tunnel construction site in Thu Thiem, Ho Chi Minh City.

Addressing the ceremony, Le Hoang Quan, Chairman of the Ho Chi Minh City People's Committee praised contractors for overcoming many obstacles and challenges to ensure pace of the tunnel construction.

He also expressed thanks to the Japanese Government and the Japan International Co-operation Agency (JICA) for financing the project, and to local people who were relocated so the project could be finished soon.

The tunnel is expected to be open to traffic by the second quarter of 2011.

The East — West Highway is a project of important significance to socio-economic development, and will contribute to the development of urban areas along the city's east — west corridor. It will also help improve the urban traffic infrastructure network, and boost development at the Thu Thiem New Urban Area and the city as a whole.

East Malaysia Tunnel road linkage plan

The State Government of East Malaysia is considering tunnel technology in constructing roads especially in highland areas of Sabah.

Deputy Chief Minister cum Infrastructure Development Minister, Tan Sri Joseph Pairin Kitingan, said his Ministry has included road tunnelling as part of its road development agenda and is currently looking into it.

"We are considering it, knowing that the initial cost is very expensive but we have to be able to justify to the authority concerned to convince them that tunnelling should be one of the considerations for the construction of our road system in Sabah," he said.

This is important in order to reduce time, avoid environmental problems and save money over the long period among others.

"We in Sabah need road engineering technology including tunnelling in order to resolve, for example, the earth movements in Ranau which are affecting our roads there," said Pairin. He said although it (tunnelling) may be very expensive in the initial run maintenance-wise it is very cheap.

"So we have to consider all these," he told reporters after he officiated on behalf of Chief Minister Datuk Seri Musa Aman the opening of the three-day Eighth International Conference on Geotechnical and Transportation Engineering (Geotropika2010) held at the Pacific Sutera, Wednesday.

The conference themed "Sustainability in Geotechnical and Transportation Engineering" was organised by Universiti Malaysia Sabah's (UMS) Faculty of Civil Engineering. Pairin said Sabah is confronted with issues pertaining to the impact that economic development has on the environment.

Achieving balanced development is no easy feat, he said, adding that the State Government has through its various enactments and policies however strives for sustainable development and promotes efforts that minimises the State's carbon footprint.

"We live in a challenging world today. We are challenged by natural hazards such as floods, hurricanes, tornadoes, volcanic eruptions, earthquakes and landslides that affect the environment that we live inÉin most cases these natural hazards lead to financial, environment and human losses," said Musa.

He said every citizen has to play their respective role in order to minimise these losses, adding from the perspective of this conference the challenges faced by geotechnical and transportation engineers are becoming complex, daunting and often extremely demanding.

Today, he said, engineers and developers would have to balance innovation with sustainability because the environmental impacts from unsustainable development would be irreversible and far too damaging.

"For example, lack of planning design and innovation for construction of roads or development of agriculture by clearing natural forest areas may cause habitat loss or habitat fragmentation," he said.

He said, likewise, poor planning of transportation management in the urban area may not address environmental issues such as increased air pollution emitted from vehicles.

Malaysia- Singapore undersea tunnel an option

An undersea tunnel between Malaysia and Singapore is an option being considered by both countries the Malaysian Transport Minister Datuk Seri Kong Cho Ha said recently.

He said the tunnel is being considered to realise the rapid transport system (RTS) between Johur Baharu and Woodlands in Singapore as agreed upon by the two countries in May 2010.

An undersea tunnel involved a high cost but was a more environmentally friendly option he said. The other option was to build another causeway. Constructing a bridge was not considered an option because merchant vessels continued to use the Straits of Johur separating the Malaysian peninsular from Singapore.

Under the agreement reached in May 2010 Johur Baharu and Singapore are to be linked by a rapid transport system by 2018.

Upper Seti tunnel making progress

Construction of the tunnel of 127 MW Upper Seti Hydropower Project is underway at Byas Municipality in Tanahun district. According to Nepal Electricity Authority, eight-meter tunnel has already been constructed as of now by Himal Hydro and General Construction Company, the contractor.

Project officials said survey of the road from Upper Seti's powerhouse to camp has been conducted. Construction of camps and roads is also ongoing with Rs. 200 million released by the government. According to the Electricity Authority, Japan International Cooperation Agency (JICA) has shown interest in the project which is estimated to cost Rs 25 billion. The government has announced that Upper Seti one of three critical projects for the country that would the "project of national pride".

How did the elephant cross the road? Underneath it

Dusk had settled on Mount Kenya's forested slopes on 24th January 2011, and traffic had slowed to a trickle on the region's major highway. That's when three elephants crossed through Africa's first dedicated elephant underpass — a new solution to the increasing problem of animal-human conflict in Africa.

The $250,000 tunnel — built with donor funds — has successfully connected two wilderness areas and two distinct elephant populations separated for years by human development. The elephants successfully crossed a major road without putting themselves or motorists in danger, and without damaging crops or scaring residents in a nearby village.

The 15-foot-high (4.5-meter-high) tunnel opened for elephant business around Christmas 2010, and on Jan. 1 a bull elephant named Tony made the first crossing. Accompanied by two other young males, Tony moved through the underpass again on Monday as an Associated Press reporter captured the first ever photos and video of elephants making use of the underpass.

Africa's wildlife is coming under increasing pressure from human development. Villages are being built and crops raised in areas that for centuries were animal wildlands. The new elephant underpass reconnected wilderness areas on Mount Kenya's highlands and the lower forests and plains, linking 2,000 elephants on Mt. Kenya with 5,000 more below.

The 9-mile (14-kilometer) man-made corridor that surrounds the tunnel allows elephants to move from low to high to search for food and mates. The fenced-in corridor will also help strengthen the elephants' gene pool. The overall corridor and tunnel project cost $1 million.

Kenya's elephant underpass may be the first in Africa but not the world. China and India have elephant underpasses, and India even has elephant overpasses.

In the U.S., a winner was announced Sunday in a contest to design a highway wildlife crossing in Vail, Colorado aimed at reducing collisions between cars and deer, coyote and bighorn sheep.

In South Africa's Addo Elephant National Park, which is fragmented by roads and railway lines, officials recently opened an elephant crossing over a road, said Megan Taplin, a park spokeswoman. She said officials have considered overhead bridges that are wide and full of vegetation to help elephants move around.

Kenya's underpass was 10 years in the making, and didn't gather much momentum until Richard Branson, owner of Virgin Atlantic, donated $250,000. The Dutch government kicked in more money and other donors stepped up. Two major farms allowed the corridor to cross through their land.

The tunnel sits in the rolling hills below Mount Kenya, near fields of young green wheat and bright yellow canola stalks. It was lined with hay and elephant dung to entice the animals through. The bucolic lands can be dangerous, though.

Light at the end of Darjeeling tunnel

The Darjeeling problem appears to be heading for a heading for a solution at last. A delegation from Gorkha Janmukti Morcha led by its president Bimal Gurung, accepted a Central proposal on elected local body.

The meeting, held in Delhi, was attended by Union Home Minister P Chidambaram and the parliamentarian from Darjeeling, Jaswant Singh.

According to the formula, elections will be held for all panchayats and municipalities of Darjeeling. The elected representatives will then elect the people who will comprise the Gorkhaland Regional Authority. "It will be the way the Rajya Sabha is constituted," said Harka Bahadur Chhetri, Morcha spokesman, who was part of the 5-member team that met Chidambaram.

Now that the proposal has been accepted by the GJM, it will be placed at a meeting of Cabinet Committee on Security, which will be convened soon. Thereafter the election for the local bodies will be started.

Luoi Hydropower Project

Cavico Corp. a major infrastructure construction, infrastructure investment, and natural resources conglomerate based in Vietnam, today announced that its subsidiary, Cavico Bridge and Tunnel, has broken through a second sub-tunnel at the A Luoi Hydropower project. Cavico excavated approximately 1.8 miles underground between two sub-tunnels

The A Luoi Hydropower plant is built on the A Sap River, located in Thua Thien Hue Province in central Vietnam. The plant is owned by the Central Hydropower Joint Stock Co., a Vietnam-based company engaged in hydropower generation. The 170-megawatt capacity hydropower plant is expected to generate approximately 686 million kilowatt-hours of energy annually for the region.

In July 2007, Cavico was awarded a contract to excavate the tunnel as well as four sub-tunnels, a surge tank, a vertical shaft, and a service access road. The Company broke through the first sub-tunnel in August. Cavico expects the A Luoi project to generate $53 million in total revenues for the Company. The headrace tunnel is 7 miles long and 3 miles wide and is considered the longest and most sophisticated tunnel to be constructed in Vietnam.

"We are pleased to achieve another breakthrough on the A Luoi Hydropower project," commented Mr. Hai Thanh Tran, vice president of Cavico. "Our efficient, highly skilled team continues to deliver top-quality work on this complex project. We remain focused on completing this project in the safest and most timely manner to generate the highest possible gross profit for our shareholders."

South Korea looks at undersea tunnels to Japan and China

South Korea is looking into the possibility of building undersea tunnels between it, China and Japan, according to the Korea Herald. South Korea's Transport Institute was recently commissioned by the Government to undertake technical and cost feasibility studies for the project, the result of which will be available by the end of 2010.

Three high-speed, undersea tunnels for trains and cars are currently being considered for the study: Korea-Korea (Mokpo-Jeju island (167km); Korea-China (Incheon-Weihai) (341km) and Korea-Japan (Busan-Fukuoka) (222.6km). The tunnels, if ever realised, are conceived as a considerable expansion of Korea's bullet train network.

However, even a start on the design of the subsea tunnels is likely to take many years due to the negotiations and agreements that will be required with China and Japan. Indeed, the tunnels are regarded as long term projects, separated by 15-20 year intervals between each.

Other obstacles to construction are the astronomical costs — each tunnel has been estimated to cost around US$86 billion and would have to be part-funded by the countries concerned. There is also resistance from some Korean parties, haunted by Japan's past imperial aspirations, who have expressed concern that one of the tunnels will allow island-based Japan a route to the main Asian continent.

The first start could be made on the Jeju tunnel before 2020.

Lawari Tunnel Update

Although the Government has decided to convert Lowari Rail Tunnel into a road tunnel to save money, yet its completion is a far cry.

The Government is releasing fund for this important project at a very low pace as only about Rs 1 billion is provided yearly for the project, said high-placed sources in the Ministry while talking to The Nation.

It is worth mentioning here that the project was converted into road project after around 20 years and now delay in funding may cause another couple of years for its completion. Recently, it was informed in a high-level meeting that 43 per cent work of the Tunnel had been completed.

The meeting was also informed that tunnel was initially designed as rail tunnel but later on it was converted into road tunnel and it was further decided to widen it for two-way traffic.

Minister for Communication Arbab Alamgir Khan has also shown dissatisfaction over the pace of work.

When contacted, Arbab Alamgir said that the shortage of funds was the main reason behind the delay in this important project. "I am making all-out efforts for the completion of this project," he said, adding that it could face further delay if funding was not released in time.

It may be mentioned here that Lowari Tunnel was part of a 1,300 km road project that would link Pakistan with Tajikistan. The Lowari Tunnel was an important project not only for the people of Chitral but also for the entire country.

PM for immediate opening of Lowari tunnel

Prime Minister Syed Yusuf Raza Gilani has directed the National Highway Authority to make immediate arrangements for opening the Lowari tunnel to help the stranded people in Chitral because of heavy snowfall in December. He directed that the movement of people should be facilitated immediately. The Prime Minister was talking to Shahzada Muhiuddin, MNA from Chitral who called on him here at his Parliament House Chamber on Wednesday evening.

The Prime Minister said that the idea of Lowari tunnel was conceived by Shaheed Zulfikar Ali Bhutto to make it possible for the people of Chitral to travel during all weathers.

Shahzada Muhiuddin thanked the Prime Minister for his personal interest into the matter.

Woomyunsan Tunnel

The first private toll tunnel in the Seoul metropolitan area

Woomyunsan Tunnel is a 3.0 km, dual two-lane toll tunnel under Mount Woomyunsan providing a direct route between the Seoul suburb of Seocho and the satellite cities of Kwachon and Anyang in Gyeonggi province. Construction on the tunnel began in August 1998, and it began operations in January 2004.

- Nature of the investment
- Voting rights

MKIF has invested in Woomyunsan Infraway Co., Ltd. (WIC), the concessionaire of Woomyunsan Tunnel, in the form of equity and subordinated loans. MKIF is a 36.0% shareholder of WIC and provided subordinated loan of KRW9.6 billion. MKIF's total investment in WIC is KRW20.3 billion.

South Korea Connects World's Largest Seabed Tunnel

The last sections of the world's largest seabed tunnel were successfully connected near the city of Busan in the southeastern end of South Korea in December 2010. The tunnel is part of the Geoga Bridge project, which directly connects Busan, Korea's second largest city, with the island of Geoje.

The tunnel, 2.5 miles long, is one of the deepest of its kind, lying 52 yards below the water's surface. It was built using ready-made tunnel segments, which were then linked underwater. The project, expected to be completed in December according to the report, will reduce travel between Busan and Geoje from 130 to 50 minutes.

The South Korean government allocated 1.9 trillion won (US$1.6 billion), for the bridge project, which it hopes will stimulate the economy in the region.

North Korea digging tunnel for nuclear test

South Korea's Chosun Ilbo daily on Wednesday cited an intelligence official from Seoul as saying a tunnel was being dug at the country's nuclear test site that could be completed in March 2011, possibly heralding a new nuclear test.

South Korea's foreign ministry said it was closely monitoring the site and said there was no concrete evidence to show the North Koreans were preparing for a third test.

The amount of earth removed from the site in Punggye township, in a northeastern region of North Korea, indicated the tunnel was about 500 meters (550 yards) deep, half the depth needed for a nuclear test, the Chosun Ilbo report said.

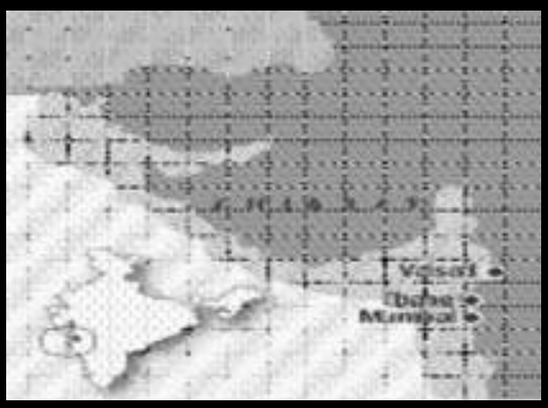
42 km tunnel and 3 dams for Mumbai

To help quench Mumbai's thirst, the state government has planned a 42-km tunnel connecting three new dams, one in Gujarat and two in Thane, a project that will enhance the city's supply by 577 million litres a day.

The dams will be over the rivers Damanganga in Gujarat, and the Pinjar and the Wagh in Thane. They are part of a project to interconnect 30 rivers across the country.

In May, then Chief Minister Ashok Chavan, Gujarat Chief Minister Narendra Modi, and Maharashtra Minister for Water Resources signed an agreement, a copy of which is with Newsline, for the dams to interlink the rivers.

The Damanganga river, over which the Bhugad dam will be built in Valsad, Gujarat, originates in Peth taluka in Nashik district and empties itself in the Daman creek. "Since the water was being emptied in the creek, it was decided to use the excess for Mumbai," said an official with the state irrigation department.



ZHENGZHOU METRO

Excavation of Zhengzhou Metro's new Line 1 in China began recently with the help of the first of two 6.3m tunnel boring machines (TBM) from US-based Robbins. The TBM was delivered to the 11th Bureau of the China Railway Construction Corporation and launched from a 16m-deep shaft. The second machine is scheduled to be launched imminently.

Both TBMs will bore parallel 3.6km tunnels beneath the city centre, linking four stations, with cover as low as 8m in places and with ground expected to consist of clay, fine sand, loess, some pebbly areas, but with little groundwater. The TBMs will line the tunnels with 300mm-thick concrete segments in a 5+1 arrangement. Curves with radii as small as 200m will be achieved using active articulation to prevent segment deformation.

Robbins' project manager Steven Zhu, said: "The most critical issue for this project is passing under Xi Liu Lake, a large body of water with a depth of 1 to 2m. The distance between the bottom of this lake and the top of the tunnel is just 7m."

Other potential problems will include passing below building foundations and highway interchanges. Injections of foam and bentonite will be used for soil conditioning in an attempt to minimise settlement. Close monitoring of the advance rate and the soil removed will also aim to prevent subsidence.

Located in east central China, just south of the Yellow River, the city of Zhengzhou is fast becoming a rail hub for the country, with many future routes planned to converge on the city. When complete in 2013, Line 1 will comprise a total of 26km of tunnel and 22 stations. Zhengzhou Metro has invested US$1.5 billion in six rail lines, which will total 188km when completed between 2015 and 2030.

Tunnels Planned for Beijing Transport

In addition to the other ideas proposed by the Beijing government to regulate the traffic in Beijing, latest planning includes construction of road tunnels to ease above-ground congestion. Beijing's traffic is no light problem. Pollution is on the rise and Beijing's wealthy residents are buying cars at astonishing new numbers. More cars hit the roads in the city every day.

The tunnels are considered will be difficult to construct due to a complex sewage system, the extensive metro as well as other planned metro routes, wiring, and cultural relics and historical sites..

The tunnels are planned on the eastern and western sides of the ring roads, where congestion is often the worst. Wangfujing pedestrian avenue will have an additional 1.2 mile tunnel under it so traffic can flow around this highly prized area more easily. Construction date for these tunnels has not been announced.

The Beijing government has announced that it plans to double the existing metro network by 1015 and triple it by 2020, which they hope will considerably ease above ground congestion.

Overhaul of Xiang'an Tunnel fire protection

The overhaul of the fire protection system in the Xiang'an Tunnel was completed on January 18 2011.

A total of 3,374 sprinklers, each with a flow capacity of 1.5 liters per second, were added to the ceiling on the right side of the tunnel, supplementing the existing ones on the left.

Whenever temperatures anywhere inside the tunnel rise above 50 degrees centigrade or suddenly shoot up by more than five degrees centigrade, the alarm system will be triggered immediately.

China tunnel links last isolated county to highway

China broke through on a road tunnel 15th December 2010 that will link its last isolated county to the national highway system. Workers danced, cheered and tossed each other in the air after blasting through the last part of a tunnel that connects the Tibetan county of Metok to China's major thoroughfare.

Metok county in eastern Tibet has a population of 11,000. Metok borders the northeastern Indian state of Arunachal Pradesh, which China claims as its territory.

The 3,310-meter-long Galongla Tunnel, built at an altitude of 3,750 meters, is a crucial project in the 117-km Metok Highway and the highway connection will be complete at the end of 2011.

The "extremely complex" meteorological and geological conditions had made the construction work arduous and difficult. Rough conditions that include elevation drops from the Himalayas to tropical rivers cut off the county about nine months of the year.

Snow and rain make the mountain roads impassable, and the walk out of the mountains can take about 10 hours.

Taipei MRT project speeds up

Engineers have used an imported double-o-tube shield machine to simultaneously dig two 1.58 kilometer tunnels beneath the Danshui River, the Department of Rapid Transit Systems under the Taipei City.

It is the first time that a DOT shield machine has ever been used in Taiwan. The two tunnels, which took 12 months to dig, will eventually become part of a new subway line joining Taipei main station and Taiwan Taoyuan International Airport.

"Use of this device has helped us overcome numerous challenges posed by the project and moved up our completion date by about six months," DORTS noted. "The DOT shield method refers to the utilization of a DOT shield machine with two cutting edges, each with 120 cutting gears," Wu Pei-jeen, director of DORT's North District Project Office, explained. "It can dig two tunnels totaling 62 square meters simultaneously, saving half the construction time."

Since 1981, a total of 18 construction works in Japan and Shanghai have employed the DOT shield technique, DORTS noted. "It is a mature, time-tested technique, very suitable for construction in densely populated areas."

Chinese Underwater Tunnel Caves in

Part of the ground atop of a cross-river tunnel in central China's Hunan Province caved in Monday 29th November 2010, forcing the evacuation of residents living nearby, local authorities said.

The ground caved in at 8:10 p.m. after sand and mud gushed into the Yingpan Road tunnel being built in Changsha, capital of Hunan, officials with the city government said.

People live in the area have been moved to safe places and no casualties have been reported.

Construction of the tunnel started in September 2009, and is expected to finish by the end of next year.

The four-lane tunnel, going through Xiangjiang River, involves about 1.87 billion yuan (280.5 million U.S. dollars) in investment.

Prosecution for Chinese subway tunnel collapse

Eight people were charged Friday in connection with a fatal subway tunnel collapse in 2008 with a crime of negligently causing serious accident in Hangzhou, capital of east China's Zhejiang Province.

Prosecutors from Xiaoshan District People's Procuratorate of Hangzhou City concluded, based on investigations, that the eight people, including the engineer, management staff, and quality supervisors of the subway project, did not take adequate surveillance measures and violated safety management rules during the construction, which finally led to the tragedy.

The prosecutors said they decided to prosecute the eight people for their criminal liabilities according to Article 134 of the Criminal Law of China. The accident occurred on Nov. 15, 2008, when a 75-meter section of the subway tunnel at the planned Xianghu Station in the suburbs of Hangzhou collapsed, leaving 21 people dead and 24 others injured.

The direct economic loss of the accident was estimated at 49.61 million yuan (about 7.4 million U.S. dollars).

Abu Dhabi waste water tunnel

Italian infrastructure group Impregilo has won a US$200 million contract from the Abu Dhabi Sewerage Services Company for the construction of a 10km stretch of wastewater tunnel. Also included in the contract are the construction of four access shafts of between 60 and 80m depth, and links to the main tunnel. The work is expected to take around three years to complete.

Significant technical and organisational complexities are involved in building the tunnel. The 7m2 excavated section will require the use of two EPB TBMs in pressures up to 8bar, simultaneously lining the tunnel with prefabricated concrete segments. It is the first time mechanised boring has been used in Abu Dhabi.

This award is the third and final lot of the Strategic Tunnel Enhancement Programme (STEP) for the construction of a 40km gravity tunnel in Abu Dhabi, which will convey waste water to a treatment plant in Al Wathba. It follows a previous US$243 million award received by Impregilo for the first 15km of tunnel on which it is currently working.

Israel's longest road tunnel

The Carmel Tunnel route, the longest of its kind in Israel, opened in Haifa in December 2010. This is not only a new traffic route but a complex project that, besides altering the surrounding environment, led to the rehabilitation of environmental damages.

In the course of construction, under the guidance of landscape architect Margalit Suchoy and agronomist Hanoch Berger, three illegal landfill sites were cleared up and some 15,000 plant bulbs such as sand-lilies and cyclamens were moved to nurseries, to be replanted in the damaged areas damaged after their rehabilitation.

The Carmelton Group, which built the project, will operate the six-kilometer route as a toll road. Connecting Haifa's eastern and western exits, the new route will spare drivers from going through traffic-congested downtown Haifa, driving up and across the Carmel Mountain or bypassing Haifa from the east. It provides an alternative route to the eastern and central parts of the city, Haifa Bay and the Krayot area, cutting current travel time from 30 to 50 minutes to six to eight minutes.

Drivers will be able to exit the tunnels to the various neighborhoods via the Rupin interchange near Haifa's Grand Canyon shopping mall, which splits the tunnels into two separate parts. The tunnel project prevented the expansive environmental damage that the construction of an overland road would have caused. But the Rupin interchange, one of the largest in Israel, was built in the heart of one of the Carmel Mountain's largest and most beautiful streams, severely damaging the environment and scenery.

To rehabilitate the landscape, local soil was returned to the slopes surrounding the interchange and natural shrubbery was planted in it. The rare white lily, which used to grow in the area, is due to be restored with nursery plant originating from another Carmel area.

An irrigation system set on the slopes will water the rock walls, enabling the natural flora to grow back.

"A tall garbage mountain used to stand here and we had to get rid of it," says Suchoy. "We tried to preserve the character of the cliffs and crags in the region as much as possible," she says.

Within 10 years, a natural, self-rehabilitating forest will have grown around the giant interchange, says Berger. "We will give it the first push by planting and watering, and nature will do the rest." Another former industrial landfill, in the Sa'adia stream and fountain near the tunnels' northern exit, has also been rehabilitated. Part of the stream bed was moved but the fountain was cleaned of waste and the natural flora has recovered.

Bahrain cooling project

Atkins has successfully completed a crucial portion of microtunnelling work beneath Bahrain's financial district, as part of the construction of the Northshore District Cooling project.

The project is the first of its kind in Bahrain and will provide chilled water to Manama's densely populated urban areas, significantly reducing the cost of providing air-conditioning to offices, residential towers and shopping malls. Air conditioning is a major component of energy usage in the Gulf region and analysts estimate that nearly 70% of all energy within the area is used to cool buildings.

The Diplomatic Area Chiller Plant, which is nearing completion, will supply chilled water to the Bahrain World Trade Centre and other developments on the south side of King Faisal Highway in the capital city of Manama. Parallel 900mm diameter insulated carbon steel pipes will be used to carry water from the Chiller Plant to Bahrain Financial Harbour, Reef Island and other north shore developments.

Using a Herrenknecht micro-tunnelling machine, Atkins successfully drove the new tunnels beneath the King Faisal Highway at a depth of 10m with zero impact on the heavy traffic above. Both were driven at an average rate of 6m/d using a laser guidance system to achieve tolerances within ± 20mm in each tunnel.

Atkins' site operations manager, Ian Cordingley comments: "It's not easy to drill through 86m of earth with such little disturbance to the surroundings. The team did a fantastic job in ensuring we deliver a chilled water network that will make the cooling of developments in Manama more economical and help in reducing Bahrain's carbon footprint."

The Northshore District Cooling project is expected to be complete by summer 2010 and will supply 22,800t/d of chilled water to a growing population.

El Alto hydropower project

Italian TBM-maker Seli has signed an engineer, procure and construct (EPC) contract in Panama for the construction of a 3.24km headrace tunnel. The project, which is to be bored by a 6.79m diameter EPB TBM, is part of the in Renacimiento district, near the border with Costa Rico.

In addition to the excavation and lining of the tunnel, the US$46 million EPC contract includes the installation of a steel lining for the last 240m of the tunnel; the construction of surge tanks; a 368m-long penstock, and a 96m high piezometric shaft.

The El Alto hydropower facility will be located downstream of Monte Lirio, and includes a 1.14 million m3 storage capacity reservoir with a head pond located at the same elevation as the Monte Lirio tailrace. The project will supply a total installed capacity of 60MW and a firm capacity of 24.7MW. The plant is expected to be completed in 2013.

This latest contract win for Seli in Panama was awarded by a Panamanian JV comprising Hydro Caisán and Panama Power Holdings. It follows on the heels of a previous contract win in the country for the supply of TBMs to the Monte Lirio and Pando headrace tunnels (World Tunnelling, News, p6, November 2010).

Design change delays Vegas intake

A contractor plans to abandon a troubled tunnel and reroute the conduit slated to serve as third underground conduit to draw drinking water from Lake Mead for the Las Vegas area.

The Las Vegas Review-Journal reported Friday that a cavern 600 feet underground filled for a third time with water and muck on Dec. 31.

Southern Nevada Water Authority engineering chief Marc Jensen says the design change could put the project up to a year behind its original 2013 completion date.

Excavation on the $700 million pipeline project stopped in July and in early December after drilling hit a fault and water and debris flooded the work area.

No one has been injured, but some mining equipment was lost to the flooding.

First use of NATM in California

Breakthrough occurred at the Devil's Slide Tunnel in November 2010, about a month ahead of schedule. It was a significant achievement, but not just for the tunneling crews and Caltrans engineers, who are building the state's first highway tunnel since the third bore of the Caldecott Tunnel opened in 1964.

When finished in 2012, the project will eliminate the region's susceptibility to isolation during winter storms, which have caused rockslides and slips with devastating impacts on access to and from several coastal communities, including Half Moon Bay, Montara and Moss Beach.

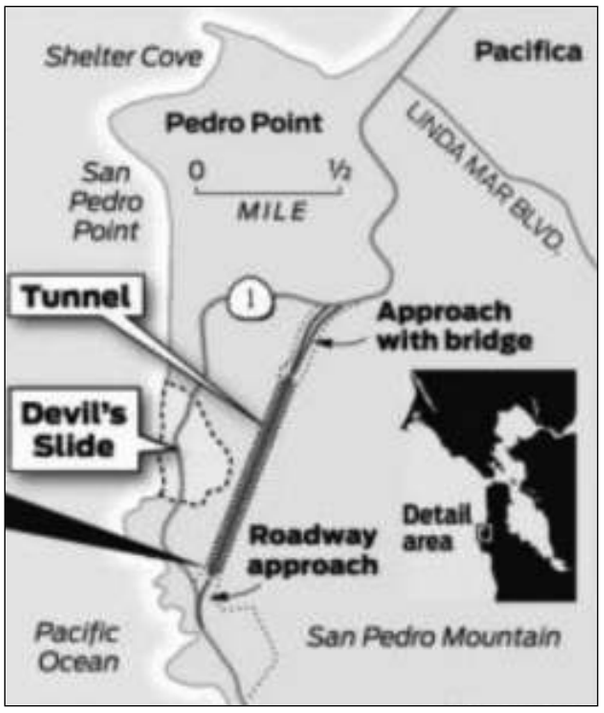
Crews have excavated two tunnels beneath San Pedro Mountain — each just over 4,000 feet long — since Caltrans broke ground on the project in Sept. 2007. About 240,000 cubic yards of soil have been removed.

The New Austrian Tunneling Method, is being used for the first time in the construction of a tunnel in California. Initial support was with shotcrete, followed by a waterproof membrane layer prior to the final lining.

A highway tunnel has not been completed in California since 1964, when the Caldecott Tunnel was finished in Alameda County. The new roadways are expected to cost $300 million, plus $42 million for the construction of two single-lane bridges that connect to the north tunnel portals near Pacifica.

The project was paid for entirely with Federal Emergency Highway Relief Funds. The existing portion of Devil's Slide and Highway 1 that will be bypassed by the new tunnels will become a public hiking and biking pathway with approximately 80 acres of public space.

The project was paid for entirely with Federal Emergency Highway Relief Funds.



Planning the world's largest water tunnel research facility

The University of Miami College of Engineering has received funding from the Corporación Andina de Fomento to undertake a feasibility study for a new experimental facility located in Panama. The proposed Water Tunnel of the Americas at the Panama Canal (WTAPC) would be the largest water tunnel facility in the world.

The experimental facility would greatly benefit the construction, naval, aerospace, and automobile industries on a global scale, by providing unique capabilities to conduct ground-breaking research. The project is aimed at advancing the fundamental understanding of aerodynamics and fluid-structure interaction and translating the findings in improved designs, analysis methodologies and tools.

"The facility would enable researchers to test models of structures they want to build, including vehicles, buildings and turbines," says Antonio Nanni, professor and chair of the UM Civil, Architectural and Environmental Engineering Department and PI of this project. "The tunnel would also enable scientists to determine forces of extreme weather on buildings and structures, by replicating real life conditions on a larger scale than it's currently possible."

The tunnel would have a test section of 4 x 4 m width by 20 m in length, and would allow a water velocity of up to 20 m/s to be maintained for 60 seconds. These characteristics would make WTAPC the largest and most advanced water tunnel facility in the world based on the size of the test section, mass flow rate and flow speed.

"A water tunnel is the natural progression from a research wind tunnel," says Nanni. "Water and wind have similar effects on structures and materials, but with water, one can maximize the dynamic effect because it's denser than air."

Existing water tunnels are closed loops that use electricity and demand energy to operate, but the new tunnel would be a "green" project, because it would use a blow-down water tunnel design that generates power by periodically allowing the water stored in the Panama Canal Maddem Dam, to flow down through the tunnel, and use the force of the water to test a broad range of man-made structures.

"We are using the force of nature to operate a research facility without impacting the energy demand," says Nanni. "The proposed design stands on sound ground from both a technical and sustainability standpoint, while the scientific and economic relevance of such a research facility for Panama and the region is unprecedented."

Once constructed and possibly coupled with existing and new UM complementary facilities such as, Miami Wind? wind tunnel, and the UM Supercomputing Center and the wind-wave-storm surge simulator, at the Rosenstiel School of Marine and Atmospheric Science, it would help create a transformational regional hub for research that would enablescientist and engineers to address the challenges of extreme weather threatening the safety of our communities and the world.

California's delta twin-tunnels

Federal and state officials threw their support Wednesday behind the construction of two underground tunnels as the best option for restoring California's freshwater delta and meeting the needs of farmers and Southern California cities.

The diversion of water from the Sacramento-San Joaquin River Delta to croplands and urban areas has furthered the decline of the largest estuary in the West. Officials are trying to find a solution to reduce the ecological stress on the delta without harming the state's agricultural economy.

Under the Bay Delta Conservation Plan, two tunnels, 33 feet in diameter and 150 feet below the surface, would deliver water from north of the delta to the south. Water users would pay the tab, an estimated $13 billion. The tunnels would take about 10 years to construct.

The federal and state initiative drew immediate protests from environmental groups, who said it doesn't include specific goals that would measure success in protecting salmon and other endangered species. They also said it failed to contain measures that would lead people to conserve water.

The delta, where the state's major rivers drain from the northern and central Sierra Nevada, is the hub of California's water supply. The state and federal government run massive pumps that siphon drinking and irrigation water to more than 25 million Californians and the Central Valley farms that grow much of the nation's fruits and vegetables.

"The status quo is not acceptable. The status quo will only result in a continuing and endless cycle of conflict, litigation and paralysis," Secretary of Interior Ken Salazar said during a conference call with reporters.

Officials said the key elements to the plan were restoring tens of thousands of acres of marshland and floodplains, and developing a new system of moving water around the delta.

Work halts on $8.7B N.Y.-N.J. tunnel

New Jersey is temporarily shutting down all new work and suspending additional contract bids on an $8.7 billion railway tunnel to New York because federal officials say the project may go as much as a billion dollars over budget — money New Jersey doesn't have.

The federal government and the Port Authority of New York and New Jersey already each are putting in $3 billion for the massive public works project, with New Jersey's share at $2.7 billion.

The suspension of all new activity — imposed by NJ Transit Executive Director James Weinstein in the wake of concerns by the Federal Transit Administration — will be used to re-examine the budget numbers.

He added that he hoped to use the time to prove to all parties involved in the project that the $8.7 billion estimate is accurate.

Work already under way, including a track underpass in North Bergen and a tunnel segment under the Palisades, will be allowed to continue. But all new work, including real estate acquisition and the awarding of one major contract already bid, will be frozen.

New Jersey officials have long considered the tunnel vital to the state's economic future as it would relieve the flow of more than 22,000 cars a day between New York and New Jersey, double the rail capacity to the city, and create 6,000 construction jobs.

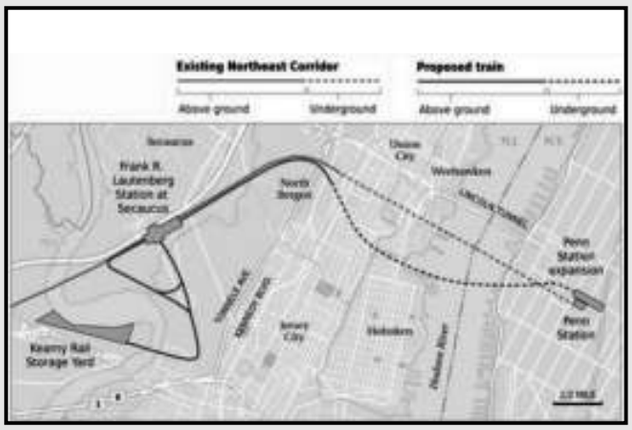
More than $600 million has been spent on the project and $1.2 billion has been committed in contracts and obligations.

The project, officially known as the Trans-Hudson Express Tunnel, is scheduled to be completed by late 2018 and is designed to more than double rail capacity between New Jersey and New York, from 23 trains per hour during peak periods to 48 trains per hour.

Under the plan, new tracks will be built from Secaucus Junction to North Bergen and the western edge of the Palisades. From there, the tracks will go under Tonnelle Avenue and into two new tunnels that will be bored more than 100 feet below ground.

The new tunnels will reach Manhattan between 28th and 29th streets, and terminate at a new rail station that will be built deep below 34th Street between 6th and 8th Avenues.

Critics have long assailed the project for its costs and shortcomings that were unavoidable because of engineering necessity.



The tunnel does not add any capacity to Amtrak. And the tracks cannot be extended to Grand Central Terminal, which would have eased congestion from New Jersey commuters who work on the East Side, because the route is blocked by a New York City water tunnel.

Forced down deep to avoid a subway line, the tracks will arrive at a rail station so far underground that commuters will have to ride up a very long escalator or ride an elevator to get to street level.

The number of people riding the trains to New York has increased more than four-fold in the past two decades — a work force that brings back $50 billion a year in income from New York to New Jersey.

Double-decker train cars and new signaling systems have helped boost the number of trains and available seats, but the bottleneck through which all New York-bound trains must travel — two, century-old tunnels originally built by the Pennsylvania Railroad and now operated by Amtrak — has reached its limit. The tunnels simply cannot accommodate any additional traffic.

But the estimated cost of the new tunnels has steadily climbed since the project was first approved. The initial projection in 2005 was $5 billion. As recently as 2008, the Federal Transit Administration had asked the state to put in as much as $1.1 billion in contingency expenses to accommodate potential increases in construction costs and interest rates, bringing the price tag from $7.6 billion up to $8.7 billion.

The new questions over the tunnel's cost come in the wake of reviews by the FTA of other high-profile New York regional transit project — some well over budget and significantly behind schedule.

According to FTA projections, the Long Island Rail Road's $7.3 billion East Side Access project was $800 million over budget and more than 18 months behind schedule. And the plan to create a Second Avenue subway line was found to be roughly $500 million over budget, and now 14 months behind schedule.

Port Mann Water Supply Tunnel

At an estimated cost of $230 million, Metro Vancouver's latest megaproject will be a big outlay for regional taxpayers, even though it's basically a glorified water pipe.

Construction begins next year on the Port Mann Water Supply Tunnel, replacing the existing water main across the Fraser River that delivers much of the drinking water for Surrey, Delta and Langley and is at a significant risk of failing.

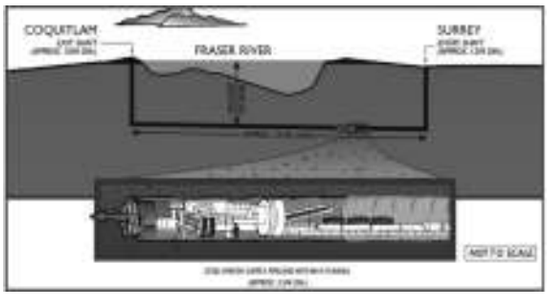
"It's a lot of money, but it's a high priority for us," says Frank Huber, Metro's division manager of engineering support and technical services.

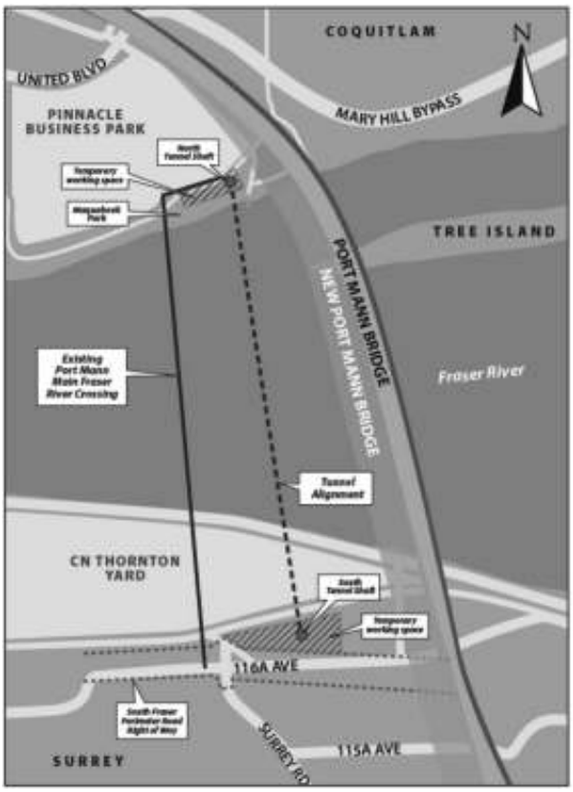
A tunnel boring machine will act like a mechanical mole to grind a one-kilometre-long tunnel 30 metres below the bottom of the river, just downstream of the Port Mann Bridge.

The completed tunnel will link up to two 60-metre deep shafts on either side of the river and ensure water from the Coquitlam reservoir continues to flow out of taps in the rapidly growing South-of-Fraser area.

It will take three to four years to complete.

When finished, the new tunnel will more than double the capacity of the existing main, which was laid in a trench at the bottom of the river in 1974 and covered in rip-rap.





Copenhagen metro extension

Italian infrastructure construction company Salini Costruttori has been awarded the contract to build the 15.5km-long Cityringen, a circular metro line which will expand Copenhagen's existing metro system. The decision was recently announced by the board of directors of Metroselskabet — owner of Copenhagen's metro which, in turn, is owned by the municipalities of Copenhagen and Frederiksberg.

Due to open in 2018, the US$3.7 billion, twin-tube line (M3) will run under downtown Copenhagen and have 17 stations. Although geotechnical surveys and archaeological excavations have already been started, the construction and operation contracts require the approval of the Danish Minister of Transport, as well as the Municipalities of Copenhagen and Frederiksberg.

Metroselskabet also announced that signal and automation systems manufacturer Ansaldo will supply trains and control systems for the new line, and will also be responsible for its operation for the first five years.

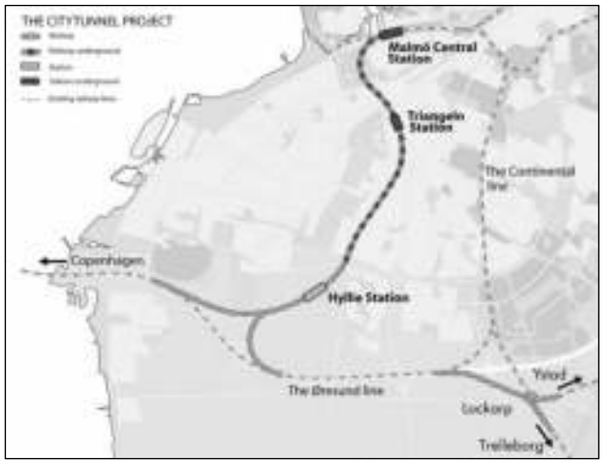
Henrik Plougmann Olsen, CEO of Metroselskabet, said: "We are looking forward to starting work so that we can provide the capital of Denmark with a cohesive metro network that will bind the city firmly together."

Copenhagen's existing metro currently comprises nearly 21km made up of two lines — M1 and M2 — opened between 2002 and 2007.

Malmo City Tunnel Project

In December 2010, a massive new railway tunnel was opened between Sweden and Denmark. It was finished six months early and nearly 10% under budget. This feat of modern engineering was completed in the Swedish city of Malmö, just across the Oresund bridge from Copenhagen, Denmark.

The project transformed Malmö Central Station, which is actually in the northern part of the city, from a dead end where trains had to reverse course into a through station. The former terminus is now just a stop on a large circular route that cuts underground through the center of Sweden's third-largest city. The construction of the tunnel was accompanied by the construction of two new stations—one in the actual city centre, and another south of the city, in an area targeted for future development



Official travel times aren't much reduced, but commuters who work in the city centre will no longer have to disembark at Malmö Central. Instead, they can use the new underground station at Triangeln, cutting a transfer to a bus or cab out of their daily grind. And as the area around the new, southernmost Hyllie Station develops, the benefits of the project should become even more apparent. Railzone's Daniel Sparing explains, "This new link virtually makes Malmö and Copenhagen a single conurbation, [making] commuting from one city to another even easier. Copenhagen airport is also extremely well connected to central Malmö and the new development area [south of the city]."

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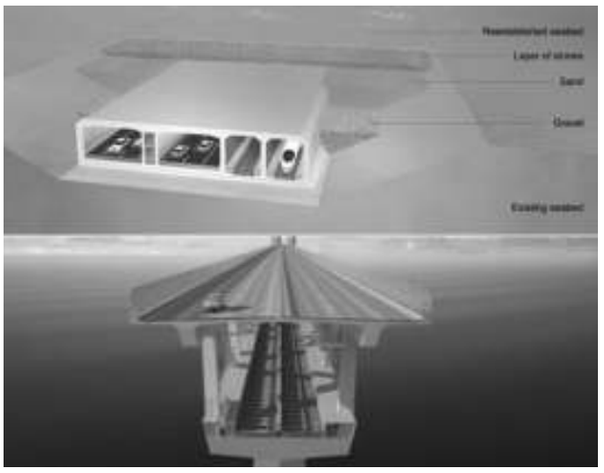


Tunnel option favoured for German-Danish link

Femern, the agency appointed by the Danish government to prepare, investigate and plan a fixed link between Denmark and Germany, has provisionally recommended an immersed tunnel in place of a cable-stayed bridge. Fehmanbelt is an 18km-wide stretch of water between Germany and Denmark.

The recommendation was based on a comparison of the various risk factors involved, including technical, environmental impact, navigational safety and construction costs. The conclusion was that the tunnel will involve less risk.

Numerous assumptions underlie Femern's recommendation, including the likely manufacture of bridge steels in the Far East, compared to the manufacture of tunnel components which, due to their great weight, would have to be made locally.

The cable-stayed bridge solution would entail two free spans of 724m each — the largest spans ever constructed for either road or rail traffic. This would pose significant risks during construction in terms of cost overruns, delays and industrial accidents, given the high volume of shipping traffic in the area. An immersed tunnel would also pose construction challenges for the same reason. But technically, unlike the cable-stayed bridge solution, an immersed tunnel would not push the limits of technology but use tried and tested techniques.

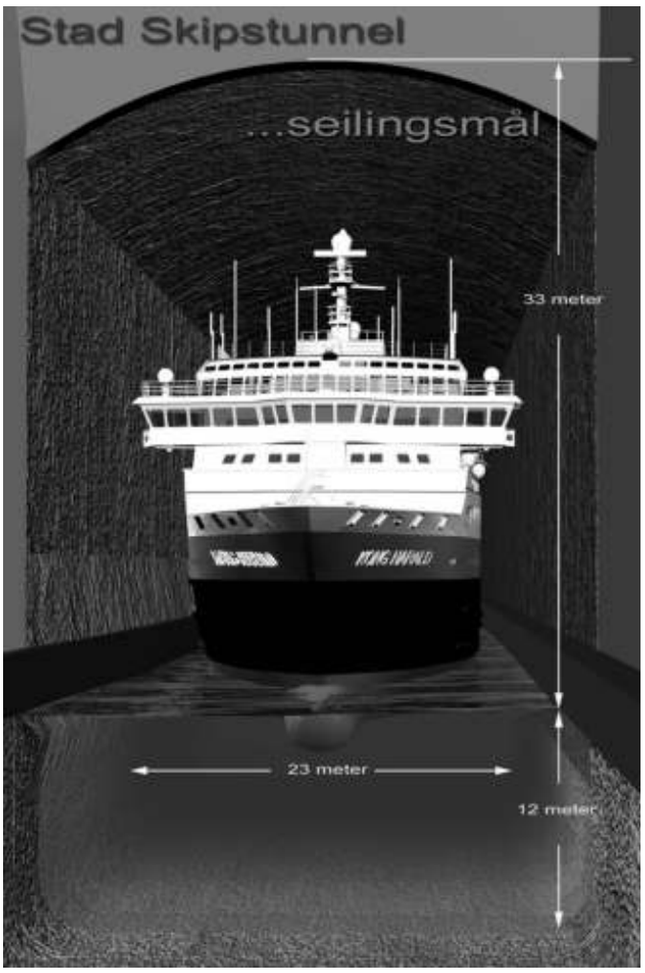
Another conclusion was that the tunnel would have a slightly lower marine environmental impact than the bridge and would also pose fewer risks in terms of navigational safety.

The recommendations are at present still provisional, A decision on which of the two options will progress the scheme to a final decision will not be made in Denmark until early 2011 and it will then be subject to approval by the German government. Construction contracts are expected to be signed in 2014.

Stad Skipstunnel

Stad Skipstunnel the world's first tunnel for ships has been approved by Kystverket which means it might be completed by 2014. 90% of all the ship traffic will go through this tunnel, passing the Stad area in southwestern Norway, one the most dangerous shipping routes in Norway which have claimed many lifes through the years.

The tunnel will be 1800m long passing under a penninsula with 500m tall mountains above. Price is estimated to around 2 billion NOK.



Two new road tunnels in Rural Iceland

The brand new Hedinsfjardargong tunnel in North Iceland opened in October 2010. The tunnel is 11 kilometres long, making it the biggest transport project ever in Iceland.

Hedinsfjardargong is, in fact, two tunnels: a 7 km tunnel between Olafsfjordur and Hedinsfjordur and a 4 km stretch between Hedinsfjordur and Siglufjordur. The car journey between the towns of Olafsfjordur and Siglufjordur (both in the Fjallabyggd municipality) is now 47 kilometres shorter than it was on Friday.

Hedinsfjardargong was first discussed in the Althingi national parliament in 1990 — but construction did not begin until four years ago. The tunnel will be a major boost to the small community of Fjallabyggd — especially during wintertime when the old roads can be very treacherous. To celebrate the day, the two towns were linked together with a 17 kilometre-long scarf which people from the local area and around the world have been making for several months.

Hedinsfjardargong cost ISK 12 billion (USD 106.7 million) to complete, which is a billion over-budget due to the large amount of water seeping into the tunnel during construction.

A week previously, the Westfjords region was also celebrating the opening of a new tunnel. The new Oshlidargong between Isafjordur (Hnifsdalur) and Bolungarvik was constructed for safety reasons. The old coastal road along Oshlid is extremely prone to rock slides, avalanches and icing in winter. Keeping the road open was a constant and expensive struggle and a real danger to the travelling public.

Jacobs receives contract for wind tunnel in Sweden

Jacobs Engineering Group Inc. has received a contract from Scania to create a climatic wind tunnel in Sweden.

Financial terms were not disclosed.

The government contractor said Tuesday that the tunnel in Sodertalje, Sweden will be used by heavy trucks and buses to test them under various conditions such as rain, high winds and snow. Jacobs will be responsible for engineering, procurement and construction services.

World's longest tunnel under Swiss Alps

The world's longest tunnel was completed beneath the Swiss Alps on October 15 2010, paving the way for continuous high-speed rail travel between northern and southeastern Europe.

The ceremonial breakthrough in the 35.4-mile long Gotthard base tunnel through the foot of the Alps took place 19 miles from one end and 2,000 meters below a mountain.

Eight of some 2,500 tunnel workers have died since construction of the new railway link began in central Switzerland 15 years ago, blasting and boring through 13 million cubic metres of rock in hot and humid conditions.

By the time it opens for service in 2017, it will exceed the 53.8-kilometer Seikan rail tunnel linking the Japanese islands of Honshu and Hokkaido and the world's longest road tunnel, the 24.5-kilometer Laerdal in Norway.

Although the near 10 billion Swiss franc (7.0 billion euro) project is Swiss, it has fast taken on a continental dimension with the aim of unclogging one of the main north-south commercial routes between Germany and Italy.

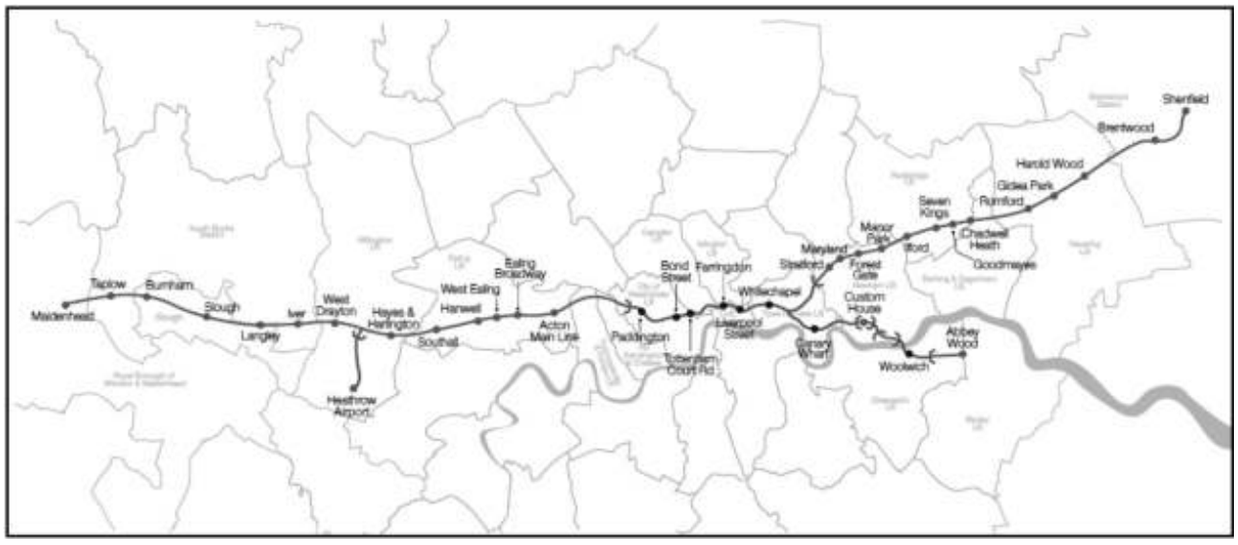
The tunnel will cut one hour from the transalpine rail journey, and drive booming road freight off congested Swiss mountain roads onto more environmentally sound rail. "The Gotthard base tunnel is a milestone on the way to taking freight traffic off the road and onto rail," said Peter Fueglistaler, director of the Federal Transport Office. Switzerland nonetheless struggled to convince sceptical European neighbours after Swiss voters supported an ecologist motion to ban heavy trucks from the Alps — including the expanding flow of transiting EU goods traffic — in a shock referendum result in 1994. In recent years, Austria, France and Italy have set in motion two similar rail tunnel projects through the eastern and western Alps.

Around 300 trains should be able to speed through the twin tubes every day, at up to 155 mph for passenger trains, according to planners. The current ageing and narrow 15-kilometer tunnel higher up the flanks of the St. Gotthard can cope with just a fraction of that capacity at less than half the speed.

It was nonetheless a global engineering feat when it was completed 128 years ago, having claimed the lives of some 200 tunnel workers. The overall cost of the new base tunnel and other revamped rail lines through the Swiss Alps will reach nearly 19 billion francs.

For locals in the mountains, meanwhile, it almost brings the 63 year-old dream of a Swiss engineer to life. In 1947 Carl Eduard Gruner envisaged not only a tunnel through the foot of the mountains at the same location, but a high speed train network that would whisk tourists between continents and allow them to stop at a gateway to the Alps.

Tentative plans for the "Porta Alpina" station halfway along the new Gotthard tunnel were shelved because of the cost, 50 million francs. But a huge cavern and evacuation siding has been prepared beneath the village of Sedrun, at the foot of an 800-meter lift shaft built by southern African mining specialists and close to some ambitious ski resorts.



Crossrail awards £1.25bn tunnel jobs

Crossrail has awarded contracts for the main project tunnel drives and four big stations. The contracts, worth in the region of £1.25bn, rank as the most significant tunnelling work to be awarded since the Jubilee Line Extension and Channel Tunnel Rail Link and will provide a much-needed boost to UK construction.

A joint venture of BAM Nuttall, Ferrovial Agroman (UK), Kier Construction picks up the big honours with one of the main tunnel drive packages plus the Tottenham Court Road and Bond Street station contract, together worth £500m.

Irish contractor John Sisk's decision to team up with Spanish construction giant Dragados proved inspired as they pick up the biggest TBM tunnel drive, worth £500m.

Balfour Beatty, Morgan Sindall, Vinci and Austrian tunnelling expert Alpine BeMo Tunnelling take the other main package worth £250m for Whitechapel and Liverpool Street stations.

The first tunnelling activity will now get underway in late 2011 and up to 14,000 people will be employed at the peak of construction between 2013 and 2015.

The contracts being awarded today are the first of nearly thirty major contracts that will be awarded by Crossrail over the next eighteen months.

The contracts, worth in the region of £1.25bn, rank as the most significant tunnelling work to be awarded since the Jubilee Line Extension and Channel Tunnel Rail Link

A further series of tunnelling contracts will be awarded in 2011 including the Thames Tunnel between Plumstead and Woolwich and remaining contracts for tunnel portals and station platform tunnels.

Crossrail winners

- **C300 — Western Running Tunnels (Royal Oak to Farringdon)** — BAM Nuttall, Ferrovial Agroman (UK), Kier Construction
- **C305 — Eastern Running Tunnels (Limmo Peninsula to Farringdon; Limmo Peninsula to Victoria Dock; Stepney Green to Pudding Mill Lane)** — Dragados, John Sisk & Son (Holdings)
- **C410 — Early access shafts and sprayed concrete lining works for Bond Street and Tottenham Court Road stations tunnels** — BAM Nuttall, Ferrovial Agroman (UK), Kier Construction
- **C510 — Early access shafts and sprayed concrete lining works for Whitechapel and Liverpool Street stations tunnels** — Alpine BeMo Tunnelling, Balfour Beatty Civil Engineering, Morgan Sindall (Infrastructure), VINCI Construction Grands Projects.

Rob Holden, Crossrail chief executive said: "Significant competition in the construction industry for Crossrail work has delivered highly competitive bids. "Over £1bn in savings to Crossrail's construction costs have been identified to-date in part due to a more efficient construction timetable and these contract awards will help secure these savings." He added: "Crossrail will award a further series of tunnel construction contracts in 2011 including the new Thames Tunnel between North Woolwich and Plumstead.

"I would like to take this opportunity to thank all of the companies and consortia who participated in these tunnel bids. "They each committed a huge amount of resource

and we look forward to working with the winners to further develop their ideas with ours to deliver Crossrail in the most efficient and cost-effective way."

In spring 2012, the first two tunnel boring machines will start on their journey from Royal Oak towards Farringdon. This will be followed later in 2012 by the launch of two further tunnel boring machines in Docklands that will head towards Farringdon under central London. Further shorter tunnel drives will take place in the Royal Docks and east London.

Tunnelling teams will work around the clock to complete the tunnels for Europe's largest infrastructure project with thousands of others employed to upgrade the existing rail network and build major new stations along the central section of the route. To construct the 21km of twin-bore tunnel required for Crossrail, seven tunnel boring machines will be used and will undertake ten individual tunnel drives and construct the 6m diameter tunnels. Each TBM will be up to 120m in length.

Construction is also underway on the new Tunnelling and Underground Construction Academy in east London. The Academy will offer training to at least 3,500 people in underground construction alone over the lifetime of the project. Currently the nearest tunnelling training centre is in Switzerland. The Academy will start to offer training in spring 2011 and the building will be fully open by summer 2011.

Tunnels and construction schedule:

A total of 21 km of twin-bore tunnel is required to be constructed for Crossrail.

The five tunnels to be constructed are:

- Royal Oak to Farringdon west (Drive X) — length of drive 6.2 km
- Limmo Peninsula in the Royal Docks to Farringdon east (Drive Y) — length of drive 8.3 km
- Stepney Green to Pudding Mill Lane (Drive Z) — length of drive 2.7 km
- Limmo Peninsula in the Royal Docks to Victoria Dock Portal (Drive G) — length of drive 0.9 km
- Plumstead to North Woolwich (Drive H) — length of drive approximately 2.6 km

London Cable Replacement Tunnel

British construction firm Costain announces that it has been awarded a contract from National Grid for its London Cable Replacement Tunnel.

The contract is worth approximately £200 million and forms part of National Grid's investment plans in the capital to ensure a continued safe and reliable electricity transmission network.

The contract is to build a new high voltage electricity cable tunnel between Hackney and Willesden (via Kensal Green) and Kensal Green and Wimbledon. The tunnel is a total of 33km long.

Works will start later this year, with the tunnelling being completed by end of 2014 and with all associated works completed in November 2018.

Preston city flood tunnel scheme

Construction work on a £114 million tunnel system to stop sewage flowing into a waterway started on January 27 2011.

Work on the first of five micro-tunnels, 27 metres below Preston in Lancashire, got underway to kick-off a scheme aimed at stopping wastewater getting into the River Ribble.

As well as the tunnels eight deep shafts are also going to be dug so the tunnels can be built.

The tunnels and shafts will create an extra 40,500 cubic metres of storm water storage for the city which according to United Utilities, the firm behind the work, is the equivalent of 16 Olympic size swimming pools.

Eventually, all five micro tunnels will connect to the already built 3.5 km long storm storage tunnel between the Preston and Penwortham.

United Utilities' principal project manager, Brian Edwards, said: "The project has been planned to help the river and the Fylde coast comply with European legislation. Once complete, improvements should be seen to river quality and shellfish waters along the estuary and to beaches at Southport, Ainsdale, St Annes and Blackpool."

During a storm the new tunnel will transport flows to the new pumping station in Penwortham, this is designed to pass up to a maximum flow of 1500 litres a second to the wastewater treatment works at Clifton Marsh.

London Underground to Re-Tunnel Bank Station

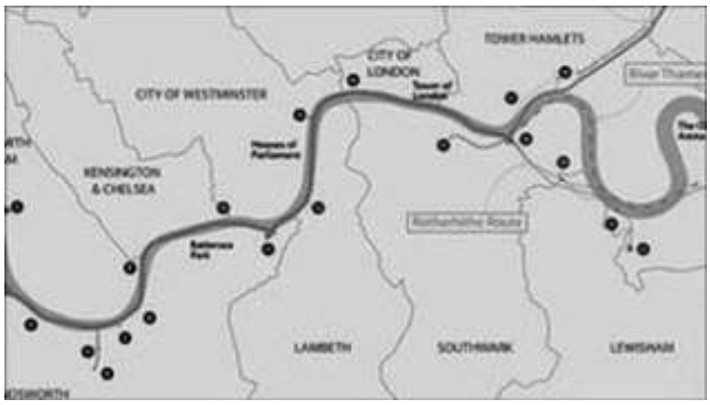
London Underground is consulting with the City of London on a long-term plan to re-tunnel parts of Bank station, in a major effort to reduce congestion on what is one of the capital's busiest Tube interchanges, and almost certainly the most difficult to navigate.

A station so big they named it twice (it is often known as the 'Bank-Monument Complex', in recognition of its sister station), the history of Bank is, much like the history of the Underground itself, a muddled tale. Constructed in 1900 as part of the City & South London line (now the Northern line), to replace a nearby terminus at King William Street, it was joined in the same year by platforms that served what was then called the Central London Railway.

In 1902, it welcomed the Waterloo & City line, and was soon yoked by an underground tunnel to the existing Monument station. Within a short space of time, three stations had become one, and the addition of the DLR platforms in 1991 further complicated matters. This map gives an idea of the labyrinthine layout beneath the City's streets.

The plans would include re-tunnelling the Northern line, giving the platforms step-free access in the process, and constructing a new entrance on King William Street.

This would complement a scheme to build a new step-free entrance to the Waterloo & City line, which is already underway. If approved, work would begin in 2015, for completion in 2021.



Thames 'super sewer' tunnel

Detailed plans for a £3.6bn tunnel to stop raw sewage polluting the River Thames have been unveiled.

The 20-mile (32km) Thames Tunnel would run from west to east London, broadly following the route of the river, collecting sewage discharge triggered by rainfall.

Concerns have been raised about the cost of the plan to water customers and the long-term environmental gain. A public consultation on the Thames Tunnel will last for 14 weeks.

The Thames Tunnel will be at a depth of about 246ft (75m) and will emerge to the east of Tower Bridge at Limehouse before going one of three ways:

North-east to connect to the Lee Tunnel at Abbey Mills in Stratford — the shortest of the proposed routes;

East following the river and crossing the Greenwich peninsular up to Beckton Sewage Works in Newham;

South-east, straight to Greenwich and then on to Beckton.

Thames Water has estimated the cost of the planned tunnel could result in bill increases of about £60 to £65 per year for its customers. The company said, on average, sewage is discharged into the Thames at least once a week due to rainfall.

Martin Baggs, Thames Water's chief executive, said: "Allowing sewage to continue to overflow into the river at the current frequency is unacceptable. This causes significant environmental damage — killing fish, polluting the river for those who wish to use and enjoy it and affecting the wellbeing of our capital. The proposed Thames Tunnel is the final and most challenging piece of the overall plan.

But west London's Hammersmith and Fulham Council is against the plan.

Council leader Stephen Greenhalgh said: "We have consistently pushed for a shorter, smarter tunnel that minimises disruption to Londoners. The gold-plated 'super sewer' with a £3.6bn price tag threatens our parks and will drive many hard-working families into water poverty to pay for it."

Thames Water hopes to submit a planning application in 2012 with construction due to be completed in 2020.

Specifying quality control measures for steel fibre reinforced concrete (SFRC)

Alan Ross CPEng IntPE(NZ)
Business Development Manager, BOSFA

Introduction

Ensuring the quality and performance of steel fibres and ultimately the steel fibre reinforced concrete (SFRC) they reinforce is critical. The challenge faced by engineers involved in designing SFRC elements is to unambiguously specify the performance required, so as to achieve in the finished structure the performance that was assumed in design.

This article discusses the importance of specifying steel fibres that can guarantee a minimum level of quality and performance and through referencing international standards and guides, provides suggestions on quality control measures that could be implemented when setting up a production facility to manufacture SFRC.

Provided there is a good distribution of reliable quality steel fibres at close enough spacing, developing cracks in the concrete matrix are quickly cut off. If this is achieved crack growth will be resisted and localised stresses redistributed, thereby providing a ductile failure mode to an otherwise brittle concrete matrix. Compare this to conventional reinforced concrete, where, because steel wire or bar is straining over larger distances, visible cracking is a natural consequence of the reinforcement carrying significant loads.

Also, conventionally reinforced concrete design is carried out using the properties of the concrete and the properties and location of the steel. Compare this to steel fibre reinforced concrete where the properties of the steel fibres and concrete are not considered on their own, but rather as constituents in a composite material. The properties of this composite material have to be determined through laboratory based testing — an appreciation of test variation, quality control and statistics is paramount to ensuring the properties used in design accurately represent the insitu concrete for the project.

Performance criteria

The fibre dosage required to achieve an effective 3-D network will depend on the fibre length, tensile strength, anchorage, distribution and number of fibres per kilogram (fibre count). Designs are then carried out based on the toughness requirements of the SFRC.

There are some basic principles that should be used and the steel fibre dosage should satisfy all of the following criteria:

- Minimum dosage to achieve sufficient fibre overlap
- Dosage required to achieve minimum performance level according to EN 14889-1[1]
- Dosage based on project performance values

Minimum fibre dosage to achieve fibre overlap, based on spacing theory

With mesh it is generally accepted that in order to control crack widths the bars should not be too far apart. Crack widths are a function of the strain and hence stress in the bar, the concrete cover and the bar spacing.

The same can be said of fibre reinforcement. If fibres are too far apart there will tend to be insufficient overlap to ensure that a developing crack will not be able to find a path between the fibres. The general spacing theory recommendation given in Brite EuRam[2] and adopted in EN14487-1[3] suggests that the maximum average spacing between fibres should not exceed 45% of the fibre length with the spacing being determined from a formula provided by McKee[4]. For structural applications such as tunnel linings the average spacing is often decreased below the 45% value nominated above.

$$\text{Average fibre spacing} = [(\text{volume of one fibre})/(\text{volume fraction of fibres})]^{1/3}$$

Where:

$$\text{Volume of one fibre} = \pi \times d2/4 \times L \text{ for round/wire fibres}$$

$$\text{Fibre volume fraction} = \text{fibre dosage in kg/m}^3 \text{ divided by the density of steel}$$

$$= w \text{ (kg/m3)} / 7850 \text{kg/m}^3$$

Substituting the maximum fibre spacing (0.45L) into the above formulae and solving for w gives the minimum fibre dosage as:

$$w = (7850 \times \pi \times d2/4 \times L)/4/(0.45L)^3$$

Which can be expressed in terms of the aspect ratio of a steel fibre (L/d) as:

$$w = (7850 \times \pi)/4/0.453/(L/d)^2$$

Table 1: Minimum dosage based on steel fibres with different aspect ratios when s = 0.45 L

Aspect Ratio (L/d)	40	45	50	55	60	65	80
Minimum dosage (kg/m^3) when s = 0.45 L	43	34	28	23	19	16	10

Minimum fibre dosage according to EN 14889-1, system 1 for structural use

This is the only performance based quality control manufacturing standard for steel fibres. In addition to monitoring and controlling the fibre characteristics that influence the performance (length, diameter, tensile strength etc) in SFRC, manufacturers must also declare a fibre dosage to meet a nominated minimum level of performance (1.5MPa at 0.5mm CMOD, and 1.0MPa at 3.5mm CMOD). This information is detailed on a CE label and for the first time designers, concrete companies etc. are presented with an opportunity to compare the expected performance of different fibres at pre-tender stage.

There are two types of classification, system 1 for structural use and system 3 for non structural use. In all cases where post crack strength values are used in design steel fibres should conform to system 1 and manufacturers should supply a Certificate of Conformity and a copy of the CE label for the respective fibre. A 'Declaration' of Conformity is not an independent 3rd party assessment of the fibre quality and should not be accepted in lieu of a Certificate.

This compares to ASTM A820-6[5], another steel fibre manufacturing standard commonly specified in project documentation. This standard, however, has no requirement to provide a minimum dosage to meet a prescribed level of SFRC performance. Manufacturers don't have to declare the target values for fibre tensile strength, length and diameter and the sampling regimes are not as stringent as EN14889-1. More importantly, testing and conformity to this standard are not always 3rd party verified. This means that the market place has no way of determining and comparing what level of quality or performance different fibre types may have when manufactured in accordance with this standard.

Dosage based on performance; residual strength values or energy absorption

The performance (ductility, toughness) of SFRC can be specified either in terms of residual/equivalent flexural strengths or as energy absorption.

Residual/equivalent flexural strengths are measured on beams[6] and must be used when SFRC is to be used in a structural design model, such as when designing precast segmental linings. This is the only test type suitable for confirming or establishing material properties that can be used in structural design and as such is the performance test discussed in this paper.

The energy absorption value measured on a square panel[7] is used, in the case of rock bolting, when the emphasis is put on the amount of energy which has to be absorbed during the deformation of rock. This approach tries to simulate the behaviour of the in-situ SFRC and gives a good indication of the actual load carrying capacity and energy absorption that can be achieved in the composite material when the reinforcement works to redistribute the stresses in the parent concrete and thereby effectively increases the load carrying capacity and energy absorption of a sprayed concrete lining.

Energy absorption can also be calculated using a round panel test[8]. This test determines the energy absorption capability of the individual components of the composite, firstly for the uncracked concrete panel and then, subsequent to cracks forming, for the fibres bridging the cracks in the panel. As such it can be suitably employed as a quality control measure for steel fibre reinforced shotcrete/concrete.

High strength or high performance concrete

The tensile strength of the fibre must be consistent with that of the concrete matrix. If there is any uncertainty or lack of control on the upper limit of concrete strength, then a high carbon (>2000MPa tensile strength[9]) steel fibre should be considered.

An example of this is where through achieving the project concrete durability requirements the net effect is an increase of the concrete strength; such as pre-cast segments in some desalination plants. Further information should be sought from the steel fibre manufacturer.

Other Engineered Products

Other engineered products such as steel, concrete and LVL (Laminated Veneer Lumber) are all manufactured under a quality controlled process where the design properties are verified in the manufacturing facility and the published and codified values are used by engineers when carrying out structural design.

There are a series of quality control 'gates' set up to measure and control the manufacturing process. When a new product is being developed extensive performance testing is carried out initially which provides a large sample of data, this enables reliable statistical analysis of results and is used to determine material properties. These properties are typically characteristic (lower fifth percentile) and 'minimum' average values.

These results and the QC data will provide evidence that the manufacturing process is in control. Once this has been established, performance testing of the finished product will reduce and the results are added to a running tally of previous data.

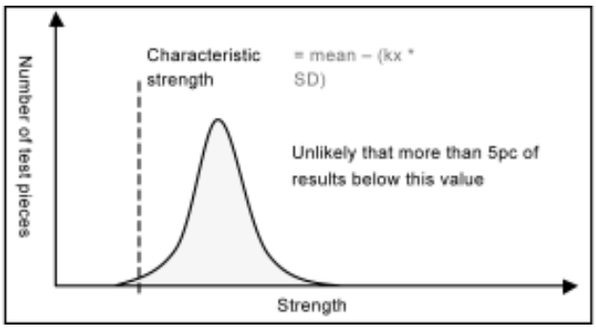
The performance testing is used as an indication of manufacturing control only; the QC gates are used on a day to day basis to monitor and control production and to ensure material is manufactured within specification.

Characteristic values

When determining material properties it is assumed that the distribution of results will be approximately 'normal', so that a frequency distribution curve of a large number of sample results would be of the form shown in **Figure 1**.

A characteristic strength is taken as that value below which it is unlikely that more than 5pc of the results will fall[10]. Common student tables can be used to determine this value based on sample size and test variation.

Figure 1: Normal distribution of strength values

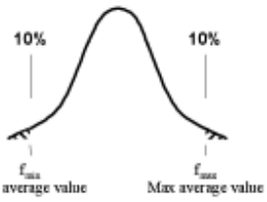


Minimum average values

The average value calculated in a sample is only an estimation of what the average will be in the whole population, in this case, all the SFRC the batching plant produces.

The size of this variation will depend on the number of units tested in the sample and the inherent standard deviation or coefficient of variation intrinsic to the nominated test method. For example, shown in **Figure 2** it is possible to see the number of units required in a test sample to achieve the same statistical accuracy (+ or — 10%) when the coefficient of variation of the test methods are different.

Figure 2: Distribution of average values for COV = 15pc & 30pc[12]



Coeff. of variation	s/av (%) = 15		
n	t90	fmin	fmax
3	1,886	0,84	1,16
4	1,638	0,88	1,12
5	1,533	0,9	1,1
6	1,476	0,91	1,09
7	1,44	0,92	1,08
8	1,415	0,92	1,08
9	1,397	0,93	1,07
10	1,383	0,93	1,07
11	1,372	0,94	1,06
12	1,363	0,94	1,06
13	1,356	0,94	1,06
14	1,35	0,95	1,05
15	1,345	0,95	1,05
20	1,328	0,96	1,04
30	1,311	0,96	1,04

RDP: min. 5
check if variation max. 15%

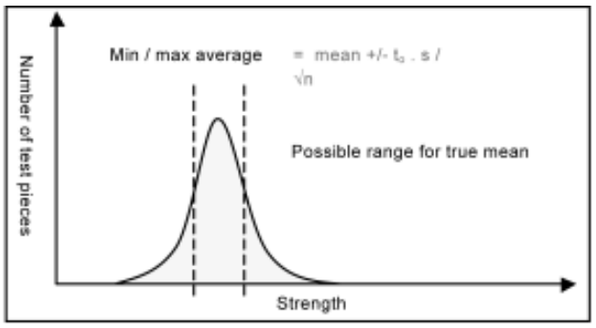
	s/av (%) = 30		
n	t90	fmin	fmax
3	1,886	0,67	1,33
4	1,638	0,75	1,25
5	1,533	0,79	1,21
6	1,476	0,82	1,18
7	1,44	0,84	1,16
8	1,415	0,85	1,15
9	1,397	0,86	1,14
10	1,383	0,87	1,13
11	1,372	0,88	1,12
12	1,363	0,88	1,12
13	1,356	0,89	1,11
14	1,35	0,89	1,11
15	1,345	0,9	1,1
20	1,328	0,91	1,09
30	1,311	0,93	1,07

Beams: min. 15
check if variation max. 30%

The minimum average (or true average) is a value that it is statistically unlikely that the average value will fall below, **Figure 3**. And as mentioned, is a function of the number of test pieces in the data set, the spread of results (COV) and a fractal taken from student tables such as the ones found in ISO 12491[11].

Both these values are influenced by the variability or scatter of test results and the number of test pieces in the sample. High variation & low number of test pieces = lower characteristic or average values.

Figure 3: Mormal distribution of strength values



What causes scatter?

The variability of the beam test has been discussed elsewhere, some references can be found at the end of this paper[12,13]. There are a number of different factors that can influence the variability of results, namely:

- Number of test pieces in a sample
- Fibre quality; consistent dimensions, tensile strength
- Ratio of fibre length to max aggregate size
- Batching and mixing
- Casting of test piece
- Size of test piece, cracked area
- Laboratory equipment and experience

Variability that can be controlled specifically through quality control is discussed further.

Number of tests

In Australia for large infrastructure projects it is common practice for ready mix companies, at tendering stage, to carry out limited testing (2 or 3 RDP panels, or 3 beams, sometimes less if a beam or panel are damaged) to confirm a fibre type and dosage to satisfy the design properties.

Statistically you can't derive properties on individual results and are penalised for small sample sizes. A consequence of this is that comparing the performance of two different SFRC mixes (same concrete strength, different fibres) can lead to grossly underestimating (or over estimating) the expected performance and it is entirely possible that two very different materials could show the same post crack strengths. This can lead to additional cost for the client if the fibre dosage has to be increased during production as test data builds.

Casting a beam

The method[14] used to cast beams for toughness testing can adversely influence results. Avoid using a small scoop to fill the beam mould, this can affect the fibre distribution and orientation and creates possible discontinuities in the mix. Sample straight into the mould preferably from a chute or conveyor or if this is not practically possible, into a large bucket which can fill the mould in one uninterrupted and consistent pouring action. Try to avoid rodding the mould to achieve compaction, rather, use external vibration.

Quality control

The philosophy should be to establish a manufacturing process for the SFRC that is in control, through setting up QC gates to measure aspects of production that will influence performance; such as checking the correct concrete constituents are being used, steel fibres are checked against CE labeling, concrete strength tests, fibre dosage and distribution etc. And to carry out enough initial beam tests to reliably establish and confirm the specification design values.

The following relate specifically to steel fibres and SFRC, similar specifications, quality control and testing should be established for the other concrete constituents and on the plain concrete; following national (or international) standards such as AS1012, AS1141 etc.

EN14487-1 Sprayed concrete, definitions, specifications and conformity

This is a good start for quality control measures for fibre reinforced concrete, it's specifically for shotcrete, but some of the sampling regimes could be applied for general SFRC production; Table 12 shows a particularly useful summary and is also included within some manufacturers literature[15].

Inspection of concrete constituents, steel fibres EN14889-1 Steel fibres for concrete

Steel fibres should comply with system 1 for structural use. CE label **and** Certificate of Conformity should be supplied to the project engineer and concrete plant.

The CE label which is attached to every pallet of product supplied to market can be used at the batching plant as part of their QC checks to ensure the correct fibre is being used. The CE label can also be used by the project engineer to ensure the minimum dosage has been satisfied and to compare the expected performance of different fibre types on offer at tender stage.

Dosing fibres

The fibres should be added in a controlled and traceable way. As such automatic dosing equipment is becoming widespread in Europe and in Australasia for tunnelling projects.

The equipment can be linked to the central batching system which allows accurate dosing and provides a record for QC documentation. A visual inspection is common practice to determine whether random distribution and the separation of collated fibres has been achieved.

Figure 4 shows two Incite dosing machines that can hold approximately 1500kg of steel fibre. When dosed using such a machine the fibres are typically supplied in 1000-1100kg bulk bags.

The one on the left has steel fibres and the one the right has micro synthetic fibres, both of which discharge the exact dose of fibres onto a conveyor belt leading to the hopper.

Figure 4: Incite dosing equipment

Steel fibre content

Various methods to determine fibre quantity in fresh or hardened concrete are well documented in several European standards[16] or guides[17], the most common of which relate to sprayed concrete but the same approach could be used for general SFRC production.

EN14487-1 defines[18] the type of structure into 3 categories, for example strengthening of the ground for a road or rail tunnel is classed as 'category 3'. This will influence the recommended minimum batch size for sampling. E.g. Every 100m3 of concrete for category 3 structures

Conformity is proven on the basis of measuring the fibre content of samples taken from the concrete mix used for production. This can be done by a wash-out test or magnetic separation of the steel fibres. **Table 2** suggests criteria for conformity.

It's important not to specify the project fibre dosage as a minimum dosage for this testing, because the only way to achieve this in absolute terms is to dose at a higher level for every batch of concrete produced.

Each test result, $\overline{m}_{SF,res}$, is derived from three partial test results, $m_{SF,i}$

Each partial test result is to be randomly taken from one batch of concrete and shall not be less than 10 litres (this is a change to the advice in EN 14721, which suggests 3 litres). The sample container shall be filled in one pour, directly from the mixer or from the conveying equipment.

The fibre dosage should be determined at least

- At the beginning of each production day
- After each interruption of the production
- After modifications or repairs of the production facility
- Once every *100m3(or as defined by the project engineer)*

Table 2: Conformity Control of the Steel fibre dosage[19]

production	quantity of n results in a row	criterion 1	criterion 2	criterion 3
		mean value of n test results $\overline{m}_{SF,n} = \frac{\sum_{1}^{n} \overline{m}_{SF}}{n}$ kg/m³	each test result $\overline{m}_{SF,res} = \frac{\sum_{1}^{3} m_{SF,j}}{3}$ kg/m³	each partial test result $m_{SF,j}$ kg/m³
initial (< 35 results)	3	$\geq 0{,}90 \cdot m_{f,targ}$	$\geq 0{,}85 \cdot m_{f,targ}$	$\geq 0{,}80 \cdot m_{f,targ}$
continuous (≥ 35 results)	≥ 15	$\geq 0{,}95 \cdot m_{f,targ}$	$\geq 0{,}85 \cdot m_{f,targ}$	$\geq 0{,}80 \cdot m_{f,targ}$
$m_{f,targ}$: target fibre dosage				

Establishing/monitoring material properties

pre-production Initial Type Testing (ITT) & Quality Production Control (QPC)

Once the quality controlled manufacturing process has been established and is in order it's then possible to carry out Initial Type Testing (ITT) to establish or confirm the specified residual flexural strength values, these are then used as the basis to compare on-going quality production control (QPC) in conjunction with the quality control measures already discussed.

The minimum number of initial tests and at what frequency for on going testing are commonly debated topics. All things remaining equal, the larger the initial sample, the more reliable the results will be. One suggestion is:

(The statistics here come from ISO 12491 *Statistical methods for quality control of building material*, this and EN 1990 are the standards typically used as the basis for establishing and monitoring material properties of engineered building products.)

Initial type testing (ITT)

Minimum of 10 beams
Target sample variation (COV = standard deviation/ average) should be ≤ 25%

Calculate characteristic value (lower 5%ile)

Calculate minimum average

Minimum average value

$\mu = x - to \cdot s / \sqrt{n}$

When:

μ = minimum average

x = sample mean

s = sample standard deviation

n = no of test pieces

t_o = from ISO 12491 table 3, when $t_p = 0.90$

Quality production control (QPC)

Individual results ≥ ITT 5%tile

Rolling min average of n = ITT test sample size ≥ ITT min average

Rolling COV of n = ITT test sample size ≤ 25%

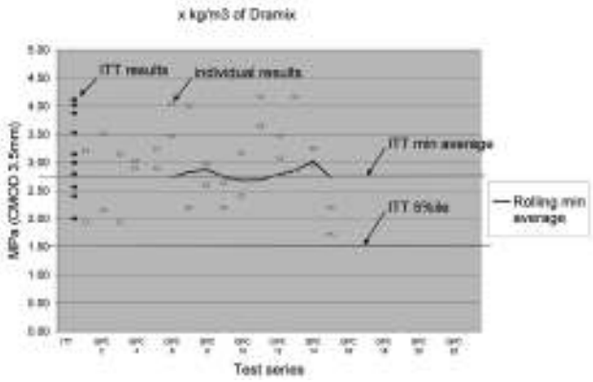
There are several different options that could be used for the frequency of this testing, for example:

- 2 beams every other day, with a rolling 10 results used to track the minimum average or
- 10 beams every 2 weeks, or other interval as decided by the project engineer

The advantage of testing beams every other day is that there is a constant check of individual results to compare against the ITT 5%tile limit.

Example of quality control graph tracking test results

Figure 3: QPC based on 2 beams per sample, tracked minimum average value based on rolling 10 QPC test results



From this example is can be seen that the minimum average value drops down slightly below the ITT min average, this should be a trigger to closely examine all other QC data, if it had continued to reduce significantly then further investigation would have been necessary. If the quality control gates are doing their job then it's

possible that this slight reduction in performance had already been picked up and corrected before the beams were tested; for example, through a drop in fibre content.

ITT should be repeated if there is a significant change in constituent materials, composition, personal or equipment such as but not restricted to:

- higher water/cement ratio;
- aggregate type or supplier;
- maximum aggregate size;
- admixtures or additions;
- cement type, class or source;
- fibre type or supplier

Conclusion

- Setting up a quality controlled manufacturing process for SFRC is critical to ensuring the properties used in design are delivered to site
- A uniform fibre content and distribution is essential to ensuring reliable and consistent SFRC properties and the toughness performance, amongst other things, is correlated to the number of fibres bridging a crack[20]
- Carrying out limited testing at tender stage to determine fibre type and dosage can underestimate the actual performance of the SFRC
- EN14889-1 is currently the only performance based manufacturing standard for steel fibres. The CE label can be used by the engineer to compare the expected performance of different fibre types and by the pre-cast plant as a QC check to ensure the correct fibre is being used in production

Future outlook

New Zealand has provisions for SFRC in their NZS3101:2006[21] Concrete Structures Standard, this means engineers can consider this material under the framework of the NZ Building Code. At this stage Australia has no such provisions.

The steel and timber industry have comprehensive manufacturing standards for their respective products. These standards detail the quality controlled manufacturing process and provide guidance on how to determine AND monitor material strength properties.

In turn these properties are intimately linked to and published in the relevant national design Standards used by engineers. A similar approach for SFRC would ensure a clear and transparent link from published material strengths to design rules for engineers and, importantly, make certain there was a consistent quality controlled process for manufacturing this exciting engineered material.

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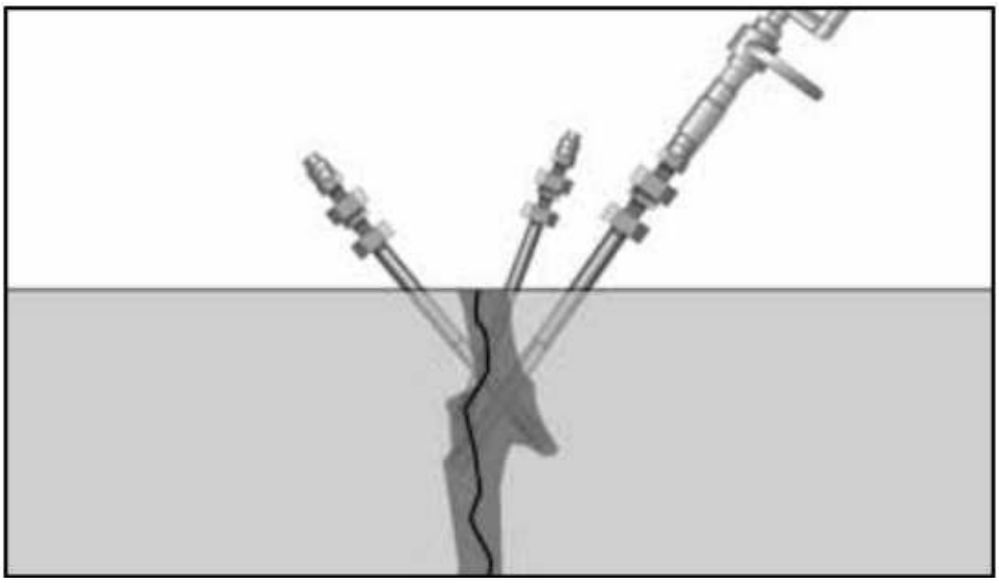


Drytech — A new solution for waterproofing Australian tunnels and basements

The ability to sustain the watertightness of the structure due to the effects of long term loading conditions is a key factor to the efficiency and economy of the overall project. The Drytech system introduces the concept of waterproofing design.

Drytech is based on the concept that all concrete cracks, and to stop the ingress of water by injection you need a medium that has the same viscosity of water to penetrate the finest cracks.

DRYflex resin

DRyflex resin is a low viscosity two component resin which seals the joint and any localised micro-cracking under positive pressure. At the time of injection the resin has the some viscosity as water, thereby saturating: cracks, joints, cavities, gravel pockets and concrete porosity.

The resin catalyses in a few minutes and when polymerised, DRY flex acrylic resins form an invisible compact gel. A particular feature which distinguishes acrylic resins from other plastic-based grouts is their capacity, after polymerisation, to swell locally upon contact with water in a controlled manner.

DRyflex resin is a low viscosity two component resin which seals the joint and any localised micro-cracking under positive pressure.

The benefits of this for waterproofing are clear enough, since, unlike polyurethanes and epoxy resins, for instance, these grouts do not require adhesion to the sides of the joint or crack to ensure a permanent seal. Even heavily soiled or oily bases hardly affect the results achieved by DRY flex. These properties are particularly beneficial for sealing micro-cracks and can achieve extremely high penetrations.

Another unusual property of acrylic resinsis their ability to enable secondary pressure grouting to penetrate the previously polymerised gel and form a new bond with the existing gel i.e. they are re-injectable. This feature is particularly advantageous when sealing joints or cracks that have opened due to local movement or building up an absolutely watertight joint.

DRY flex can also cope with long term drying and wetting as well in close location with most industrial waste.

The seal is achieved through pressure from swelling and not adhesion to the sides of the crack.

It is important to note that the waterproofing cannot be damaged as it is part of the structure, it is within the concrete itself. The system also provides the real possibility to maintain the waterproofing over time by reinjection.

DRYset channels

Joints are prepared with DRYset channels that ensure rapid and widespread diffusion of the DRYflex resin.

The special open foam of the DRY set injection channels and crack inducers ensure close contact to the concrete surface.

Drytech enables continuous uninterrupted pouring of concrete by the intelligent employment of injectable shear key crack inducers. This consequently improves production times of major pours by at least 30% and permits savings in concrete reinforcement.

DRYtech call their complete waterproofing approach the Drytech White Tank System. This is based on a single structure of watertight concrete combined with the waterproofing of cracks, joints, penetrations and openings by injecting a two-component expanding DRYflex resin.

Any necessary repairs can be easily undertaken from inside of the structure using injection techniques, without demolition or external excavation and without restrictions to the normal operation of the building.

DRYtech is a cost effective solution for waterproofing that guarantees a watertight solution. GFWAust are proud to introduce this technique in Australia and has recently employed the technique to seal the portals of the pipejack tunnel at Burrows Road in St Peters.

If you would like more information on this technique or would like us to review how this technique could be applied to your project please contact David Lees email: d.lees@gfwaust.com

BROKEN HILL, NSW

Geology

The **Broken Hill Ore Deposit** is located underneath Broken Hill in western New South Wales, Australia, and is the namesake for the town. It is arguably the world's richest and largest zinc-lead ore deposit. Broken Hill's massive orebody, which formed about 1,800 million years ago, has proved to be among the world's largest silver-lead-zinc mineral deposits. The orebody is shaped like a boomerang plunging into the earth at its ends and outcropping in the centre. The protruding tip of the orebody stood out as a jagged rocky ridge amongst undulating plain country on either side. This was known as the broken hill by early pastoralists. Miners called the ore body the Line of Lode. A unique mineral recently identified from Broken Hill has been named Nyholmite after one of the city's famous sons Ron Nyholm (1917–1971).

Discovery

The Broken Hill ore deposit was discovered in 1883 by boundary rider Charles Rasp, who discovered the gossan or weathered sulfide outcrop of massive lead-zinc sulfides on a feature known as Broken Hill. Rasp reported finding massive galena, sphalerite, cerussite and other oxide minerals, but was most concerned with the galena, a primary source of lead. His reports, believed exaggerated at the time, of masses of lead in the desert, soon proved true and sparked a 'lead rush' similar to gold rushes.

Old Kintore headframe, now a museum exhibit, Broken Hill

Exploitation

Broken Hill was exploited initially by small prospectors working the gossan for easily won galena, and soon dozens of shafts were sunk. Ore was carted to South Australia by camel trains, wagons and pack mules. A major secondary source of income became apparent, with extremely high silver grades recovered, including native silver, and other rare silver minerals present in abundance. Mining has gradually moved away from the initial small prospectors, in line with the experience in all other major mineral fields, toward gradual consolidation of claims and tenure, an increase in tenure and mine size and efficiencies in operations resulting in smaller workforces. This has accelerated in the last part of the 20th century via the formation of the Broken Hill.

Chlorargyrite lining a vug in gossan at Broken Hill

Proprietary Company — now BHP Billiton — and its exit from Broken Hill, toward only two operators at present, utilising highly efficient bulk underground mechanised mining.

Economy

Broken Hill has been and still is a town dominated by the mining industry. The mines founded on the Broken Hill Ore Deposit — the world's richest lead-zinc ore body — have until recently provided the majority of direct employment and indirect employment in the city. The Broken Hill Proprietary Company became Australia's largest mining company, and later became part of the world's largest mining company, BHP Billiton.

In the past, before the 1940s, mining was achieved via hand with high labor utilisation rates and included horse-drawn carts underground. The advent of diesel powered mining equipment in the late 1940s and the move toward mechanised underground mining has resulted in lower labor utilisation per tonne of ore recovered, and this has seen the workforce in the mines shrink. Another factor in the shrinking of workforce size has been the consolidation of mining leases and operators, from several dozen to just two main operators at present.

While the labor force has been in decline due to the low metal prices of the 1990s, which saw the failure of miner Pasminco Ltd, recent resurgence in metal prices has returned the sole existing operator, Perilya Limited, to profitability and prompted Consolidated Broken Hill Limited to advance development of the previously unmined Western Lodes and Centenary Lodes. This has involved creation of over 70 jobs during development and will see a second, new, milling operation built within the town. Although the mining industry is resurgent, labor utilisation will remain low.

Due to its exposure to the vagaries of the mining industry, and because of a swiftly shrinking population, similar to other rural centres, and compounded by its isolation, Broken Hill has actively encouraged its artistic credentials and is promoting itself as a tourism destination in order to become less reliant upon mining as a source of employment.

Spessartine garnet crystals in massive galena, Broken Hill

Thompson tunnel battle continues

Recent research on the Horseshoe Bend tunnel indicates it may obstruct a vulnerable fish species from migrating up the Thomson River. But the Friends of the Tunnel group reject the findings and have begun conducting their own testing at the tunnel site.

For almost 100 years the Thomson River has flowed through the Horseshoe Bend Tunnel near Walhalla, but a public consultation process could result in a portion of the river flow being diverted back to its original course.

The tunnel was carved by miners in 1911 so they could divert the flow of the Thomson River and search for gold in the old riverbed.

The tunnel was included on the Victorian Heritage Register in 2002 as a result of requests by the 'Friends of the Tunnel' group, and members of the group view the tunnel as a lasting symbol of the determination and ingenuity of the gold miners.

But research conducted by a leading body for freshwater ecology, the Arthur Rylah Institute, and a private consulting firm called Alluvium, has found the tunnel may obstruct a native fish species called the Australian Grayling from migrating up the Thomson River.

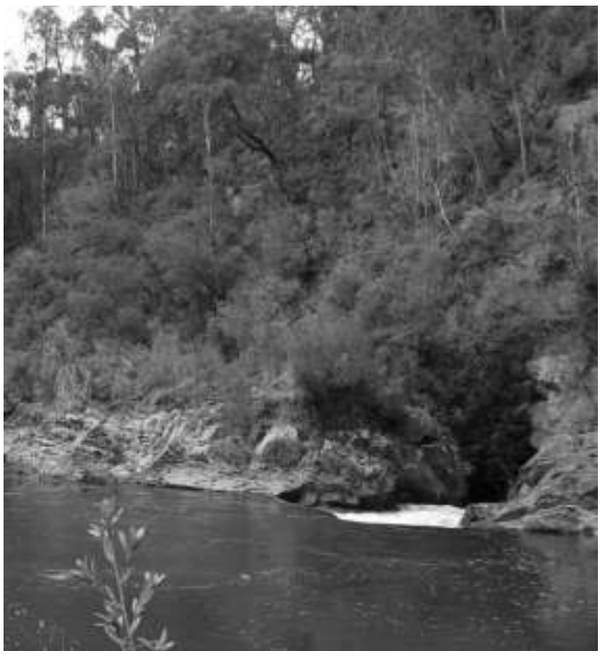
The Grayling has been listed as Vulnerable under the Australian Government Environment Protection and Biodiversity Conservation Act 1999.

The West Gippsland Catchment Management Authority engaged the two independent bodies to conduct research, interview the stakeholders and present findings considering the tunnels impact on the health of the Thomson River.

Kylie Debono, the Water Manager at West Gippsland Catchment Management Authority, says the consultants have outlined four options for restoring flows around the Horseshoe Bend section of the Thomson River, none of which involve fully closing the tunnel.

"They looked at answering the question of whether or not the tunnel was actually a barrier to fish passage," she says. "That report is still in draft form but basically what its saying is that there are few things that are limiting the passage of native fish through the tunnel and one is the flow velocity."

Ms Debono says the preliminary research findings indicate the force of water prevents the Australian Grayling from migrating upstream to the alpine reaches of the Thomson Aberfeldy system. "Even at low-flows the velocity of water is two times the birth swimming velocity of some common native fish species," she says."In particular the ones we are looking at are the Galaxias and the Australian Grayling. This is not even considering sustained swimming velocity, but that short burst velocity that they need to move from a ripple into another resting area, which we call pools. So it's unlikely that they would be able to sustain movement through the tunnel."

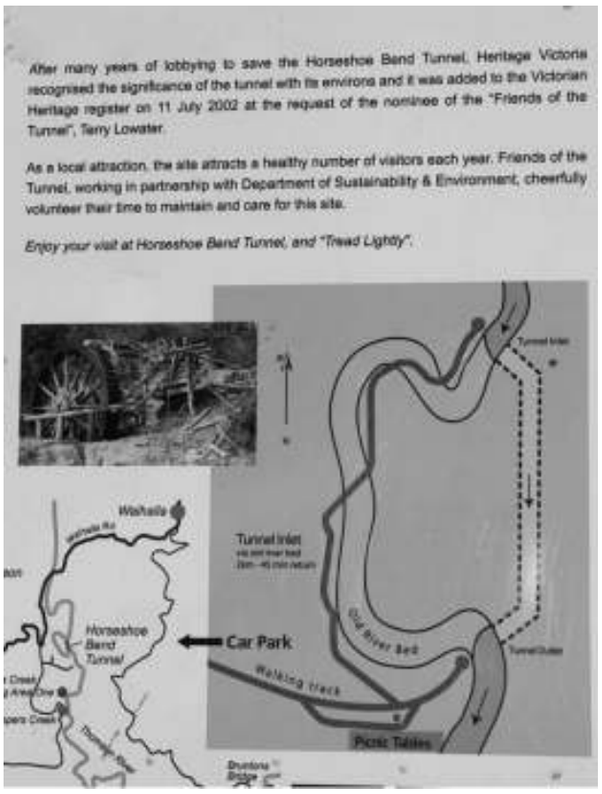


But the Friends of the Horseshoe Bend Tunnel group, which are committed to the promotion and protection of the tunnel, question whether there are any Australian Graylings present in the river.

With the use of underwater cameras, temperature gauges, and a device to measure water velocity, the group are trying to prove that the tunnel does not obstruct fish passage. "The poor old tunnel is getting the blame for the Thomson Dam and it just seems a bit unfair," says Terry Lowater of the Friends of the Tunnel group. Mr Lowater claims that if more water was released from the Thomson Dam, then native fish could move along the old riverbed, which he refers to as a 'wetland.' "I think there needs to be more people coming along to see that is the case. With a little bit of enhancement of water flows or a little bit of change to flows released from the Thomson dam, things could certainly improve through the wetlands."

But Kylie Debono of WGCMA rejects any notion that increased flows from the Thomson Dam would make it easier for fish to swim through the tunnel. "Adding more water will increase the velocity or flow of water through the tunnel, making it harder for native fish to migrate through the tunnel. You need to then also factor in light availability. Darkness has been identified through a range of studies and scientific experiments to be a behavioural barrier to native fish migration." Ms Debono says the tests conducted by the Friends of the Tunnel will be taken into account, but "it's hard to go past scientific experts when we're looking at this question of whether the tunnel is a barrier to fish passage." She says the CMA has an obligation under its statutory responsibilities to consider the health of the river along with environmental and heritage values, and this process has been thoroughly adhered to in the due diligence investigation of the tunnel site.

More public consultation sessions on the future of the tunnel will take place. But Mr Lowater says his group will continue fight any move to try and divert water out of the tunnel. "We love the place and you'll do anything for something that's part of you," he says. "We've all got this in our hearts here. We'll do anything to try and keep it alive and for tourists and kids to come and see it. It's a major drawcard to Gippsland and it really needs looking after."



The Spray Tunnel
Zeehan, Tasmania

The Spray Tunnel is a short tunnel along a historial railway line used for the transportation of ore from the nearby Spray Mine. The tunnel is easy to find as it is signposted out of Zeehan. It is part of an old railway line which transported ore from the Spray Mine to the smelters south of Zeehan.

During 1901 the British Zeehan Silver Mining Company extended the Argent tramway through a tunnel through a hill south of the Zeehan Golf Course to access the Spray mine which was located in near inaccessable country owing to the small but steep hilly country in its vicinity. The company bought a small locomotive called "Spray" which was used on the tramway until the spray mine closed in 1913.

The tunnel is an unusual 'keyhole' shape which is said to be the result of the top part of the tunnel having been enlarged to allow the passage of steam boilers that were brought through the tunnel to the mine. The first mining leases were taken up in the area in 1887 and by 1890 an adit about 80 metres long had been driven with little financial reward along an ore body about one metre wide.

The miners were looking for silver bearing lead ore. Little else was done until 1990 when antimony bearing silver lead ore was found there, some of which were assayed over 2000 ounces of silver per ton (over 60,000 grams per tonne). This was exceptional and created a great deal of excitement at the time. During the next few years the Spray mine became one of the most important in Zeehan. Between 1905 and 1908 the No. 1 shaft was sank to a depth of about 120 metres.

The site of this shaft lies directly in front of the tunnel opening amongst the regrowth at the foot of the hill, it was closed in 1909 due to flooding. Photographs showing the construction of the shaft headframe and associated buildings can be seen in the West Coast Pioneers' Memorial Museum at Zeehan. These photographs show the area completely devoid of vegetation with little left but tree stumps. Much different to what you see today, a testimony of the West Coast's environmental ability to reclaim as its own again soon after man decides he has had enough and deserts his former places of toil to move on elsewhere to further seek his fortune.

Hopes to re-open historic KVR tunnel

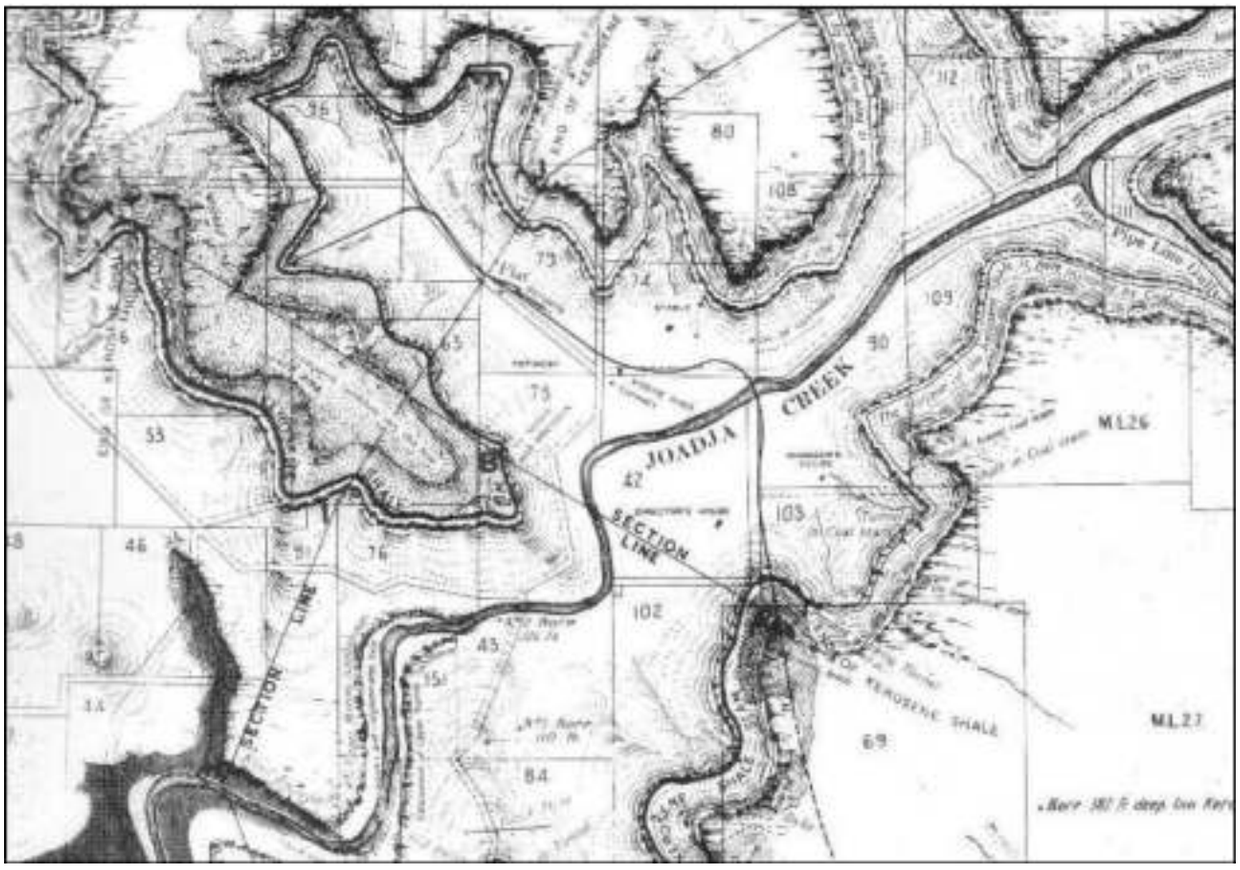
A key piece of the historic Kettle Valley Railway trail is located in the Okanagan Valley in British Columbia.

The Adra tunnel near Naramata is a half kilometre long enclosed train tunnel, but it has been closed to the public for nearly 20 years due to safety concerns.

Rocks and timber have fallen down inside the tunnel, making it all but blocked even for those willing to take the risk. But a group called the KVR Woodwackers is hoping to get the money needed to re-open it. The volunteer group will be making a presentation to the Regional District on Thursday.

They are hoping the tunnel will be selected for a $400,000 BC Towns for Tomorrow grant, which would go towards re-opening it. However, the grant would only cover part of the cost of the project.

Stu Berry, a member of the Woodwackers, says an engineering report shows $1 million is needed to fix the tunnel. The group believes the repairs are worth the cost to make the Trans Canada trail continuous.



JOADJA – New South Wales

Oil-shale in the nineteenth century was an alternative source of crude oil to the oil-wells of America and elsewhere. The Australian industry, centred in New South Wales, had close links with Scotland through technology, managers, miners and refinery workers, Joadja preserves to an extent unique in the world legible (and scenic) archaeological testimony of all aspects of a major works using horizontal retorts to distil oil from extremely rich oil-shale deposits, The article analyses these remains, both industrial and domestic, in 'the context ofother shale sites, with special emphasis on Joadja'sfour benches of retorts,

In the l850s, however, just as the oil-well technology was developing, a different source for oil created a major industry in several countries, most notably the USA, Scotland, Wales and France, followed in the l860s by Australia. This alternative source is conveniently known as oil-shale, although this is an imprecise and geologically unsound generality for the variety of bituminous minerals which have been roasted to extract oil. H.M. Cadell, a Scottish geologist and industrialist, gave a classic exposition of the distinctions more than eighty years ago: 'Oil shale differs in origin from most kinds of coal in being an undoubted aqueous deposit or precipitate composed generally of 70 to 75 per cent. of ash, originally inorganic mud, with 30 to 25 per cent. of organic matter, partly animal and partly vegetable in origin, from which the valuable hydrocarbons and ammonia are obtained. The distinction between oil-shale and the various forms of cannel coal is still best defined by the dual means of ash content and density, with the higher ranges of each characteristic of shales and the lower of cannels, while the oil-yield in general varies inversely as the density.

It is unfortunate that so many unfamiliar names have been employed for the raw materials, 'Canne!' is simply the Scots and North of England dialect pronunciation of 'candle' and in origin a lay name for coals which had apparent lighting qualities; 'boghead' or 'torbanite', the first oil-bearing mineral to be used commercially in Scotland, took its names from the location of the mines in the Lothians; the term 'kerosene shale' used familiarly in New South Wales is applied to minerals which are very similar to boghead or torbanite in Scotland. In this discussion of Australian industry, the term 'oil-shale' will be used. The basic distinction between obtaining oil from wells and oil from shale or cannel is simply that shale or cannel requires an intermediate retorting and distilling stage before refining.

Crude oil from wells goes straight to a refinery; oil-shale or cannel is mined like coal, either by adit or by shaft, and then has to go through retorting and distillation before the crude oil ready for refining is produced.

Because of the intermediate processing and the additional cost and uncertainty of mining, the shale and cannel industry was immediately threatened by the instant crude oil pumped from wells, In the USA the oil-wells virtually eradicated a flourishing oil-shale industry in the 1860s and in the Englishspeaking world the most serious continuing exploitation of shale and cannel in the later nineteenth century was in Scotland and New South Wales, In Scotland it was severely localised in the Lothians west of Edinburgh; in New South Wales the worked deposits were associated with the southern and western coalfields, usually in valleys hard of access.

The archaeology of the industry reflects three separate elements: the mines, the retorts and the refinery, Many smaller concerns produced crude oil only; those which also refined might or might not have their refinery adjacent to their retorts; some companies existed only to refine crude oil from any outside source. The mines might or might not be owned by the oil-company and were not necessarily close to the retorts, although in most cases a tramway no more than a few kilometres long connected the mine with the distillation plant.

In Australia integrated plants were common, but not universal. The Pioneer Kerosene Works at American Creek, Mount Kembla, opened in 1865 with its own retorts and refinery beside the mine. In the same year Petrolea Vale, the earlier of the two oil companies established in Hartley Vale in the 1860s, also had a plant complex on site five hundred metres from the mine-adits. 12 In 1870 Petrolea Vale amalgamated with the other Hartley Vale company, the Western Kerosene Company, Western Kerosene had chosen to build its processing plant in Sydney, at Waterloo in 1868, By 1872 the Petrolea Vale retorts and refinery had been crudely demolished: 'stills, which must have cost fabulous sums, having lost their centre of gravity, cock up their heads at all manner of angles in the most rowdy and rollicking style, just for all the world as if it had been rum and not oil which they had been accustomed to. An American visitor described Hartley Vale in 1871 as 'a most eternal fire bed of shale and a heap of old iron' .

From Petrolea Vale's closure up to 1878, American Creek's Pioneer Kerosene Works was the only integrated shale mining and processing plant in Australia. ls And American Creek closed just as Joadja was opening as the next integrated oilshale operation in the country.

OIL-SHALE PRODUCTION AT JOADJA

The valley of Joadja Creek proved to have the richest shale seams in the world but in terrain much more difficult of access than American Creek or Hartley Vale. The valley is almost entirely surrounded by dominating cliffs as Joadja Creek cut its way west to join the Wingecarribee River 14 kilometres north-west of Berrima. The first white people to enter the valley were stockmen with cattle either from the adjacent Burragorang wilderness or from the Canyonleigh .area of the Southern Highlands. The family which used JoadJa regularly were the Carters and it is a Carter who first realised the potential of the outcropping shale seams. The cattle belonged to Benjamin Carter, an English farmer who had come to New South

Wales in 1833 and settled at Sherwood on Emu Creek south-west of Berrima in the l840s, after a period as overseer at the major Sutton Forest property of Newbury. Benjamin's only son, Edward, born in 1823 or 1824, assisted his father and succeeded to his extensive grazing lands in 1857. Although Edward had been in Joadja in the early l850s and had noticed the shiny black mineral on seams out-cropping high up on the cliffs, it was only after American Creek and Hartley Vale became well-known that Carter moved to take out land-grants and mineral leases. He was primarily a farmer. In 1870 he had built the delightful two-storeyed sandstone house in Sutton Forest known as Golden Vale (where the house and Carter's extensive outbuildings are stilLin excellent order today). This was country Carter knew well, since it is adjacent to Nicholson's Newbury where he had grown up in the later 1830s. Carter's flirtation with Joadja is important historically and archaeologically, but it is no more than an uncharacteristic episode in the life of a successful grazier.

Carter's sequence of land acquisitions around Joadja Creek and its junction with the Wingecarribee River are revealing. He did not seek to control the whole area and by the later 1870s held only five portions in the critically important shale-bearing part of the valley north of Joadja Creek and two to the south totalling 305 acres (123 hectares). All five portions north of the creek abutted.

Carter controlled both major fords, one where Joadja Creek bifurcated around a long sand-island, the other further east near the shale-mines. He also controlled most of the dray-road north through Carter's Flat up to Siphon Gully, the northern end of the oil-shale outcrops. What Carter did not control was the only viable exit from the valley to the railhead at Mittagong, which climbed the cliff-face in portion 84, taken up in 1876 by George Larkin and William McCourt.

The original entry to the valley is said to have gone north to the Wombeyan Caves Road just east of the Bullio tunnel at the present Madang property. This would have left Joadja to the harth-west via Carter's Flat and the hills to its west: it was from the north-west that Edward Carter had entered Joadja Valley in 1852. But although this track avoided the severe grades of the southern route, the lure of the railway was decisive. The drayroad which survives today, known locally as Carter's Track, is of special importance for the archaeology of ore-haulage.

The need for haulage developed in the mid-1870s. In 1873 both Carter and an entrepreneur called Cosgrave applied for the conditional purchase of portion, which includes

some of the richest shale outcrops. Carter succeeded in establishing title in 1874 and immediately engaged Robert Longmore, who had the plant at American Creek in 1865, to mine the shale. In the same year 1874 George Larkin obtained mineral rights in portion, immediately to the south of and including a valuable stretch of shale, which Larkin proceeded to mine. He presumably used the ford on Carter's portion and the track up the southerly escarpment which was not yet owned by anyone.

The principal shale-mining potential lay up Russell's Gully north of Carter's portion, and the relevant portions here, and were acquired by John de Villiers Lamb. In conjunction with William Brown, Lamb also began mining in 1874. All three parties to the early shale-mining, Carter, Larkin and Lamb with Brown, were dependent on each other's goodwill for transporting the ore out of the valley.

Initially in 1874–1875, teams of fourteen bullocks hauled the ore-drays across the valley floor, over the steep-banked ford and up the zig-zag to the plateau which extended to Mittagong. This zig-zag still exists, just at the shale horizon (which is fairly close to the top of the cliffs), and is acutely hazardous for a four-wheel-drive vehicle today. It was even more hazardous for a labouring bullock-train in 1875 and an incline was constructed instead to by-pass the zig-zag. Carter had already installed a gravity incline at his mine on the north side of the valley, using a double cable: as full skips descended, empty skips rose. The full skips discharged into a 50-tonne bin, from which the bullock-drays were loaded.

On the southern side, on the still unclaimed portion, a horse-powered incline was installed, almost certainly by Carter. Two horses turned a whim on a circular platform 11 metres in diameter which is identifiable still. It is about 300 metres away from the four notches in the rock face which held the topmost rails for the descending and ascending oreskips.

Ten metres below this cutting, three more cuttings survive in bedrock to continue the support of the rails and a blacksmith-made iron spike 17 centimetres long used for securing the rails to sleepers lies in the bush just below. Down the steep slope of the incline, on its south-western side, there are five charred mortised posts parallel to the former tramway. These are clearly part of the fence line which kept stock away from the incline during its brief period of use, from 1875 or 1876 to 1878. Traffic on the incline was not heavy: the total quantity of shale mined in 1876 was 400 tonnes, in 1877, 650 tonnes. The principal steady market during Carter's period of mining was the Australian Gas-light Company which used 30 to 50 tonnes a week to enhance the quality of its gas.

The principal shale-mining potential lay up Russell's Gully north of Carter's portion, and the relevant portions here, and were acquired by John de Villiers Lamb.

According to Carter, however, there was also export of the untreated shale to America, England and Melbourne in the years 1875 to 1877.

The whole scale of the enterprise changed in 1877–1878 when de Villiers Lamb, who controlled all the significant shale, started drilling land north of the creek not in Carter's hands, was joined by Parbury to form a company Parbury, Lamb & Co. In 87 this company took the immediate, decisive step of dllling a major incline out of the south side of the valley, on Lamb's portion, 1200 metres north-east of Carter's exit. The incline goes austerely up 840 metres to the plateau, Where it was intended to join a private railway leading south line at Mittagong.

The 1877 incline was powered by a 40 horsepower steamengine located on the plateau. The magnificent winding wheels, 280 centimetres in diameter, still survive on their concrete supports with many traces of the winding-shed and railway station still discernible. The incline was single track, with the haulage cable running in the middle of the tramway.

At the bottom, it separated into two lines, running north to the creek on well defined embankments. The railway crossed the creek on a bridge supported by five piers constructed of stone rubble with concrete render, scored to resemble masonry blocks. Once across Joadja Creek, the railway went north-west across the flat where the refinery was built in 1878–1879 and up Russell's Gully to the major concentration of mines.

The advice of a leading Scottish oil-shale engineer had been sought in 1876 and the expertise of James Walter Fell, who was at that time manager of Hartley Vale's Waterloo oilrefinery, was of critical importance. Fell himself transferred from Waterloo to Lamb's employment at Joadja in March 1877, while retaining an advisory position with the North Shore Gas Works. In the same year, James' uncle, Alexander Morrison Fell, came to Joadja after managing a Scottish oilworks in the Lothians.

All that remained was the formation of a company with ample capital. The crucial decision to build retorts and a refinery at Joadja and not to depend on railing all ore to Sydney for treatment, was taken in 1877 by Lamb, his associate Parbury and his new partner Robert Sadclington, in conjunction with the Fells. In 1878 the consortium was transformed into the Australian Kerosene Oil and Mineral Co. (AKa). The new company over the next three years systematically bought up all the mining conditional purchases held by Larkin and McCourt, and by Carter, as well as all the leases already held by John de Villiers Lamb and Saddington. Effectively the mining area of Joadja became a private fiefdom of the AKa not just until the mines closed in 1903 but until the company went into liquidation in 1911: and even then the name AKa remained a brandname for the orchard produce from the valley up to 1928.

There was no hiccough between Lamb and AKa; it was a seamless transfer to a more broadly based company.

Edward Carter was not interested in becoming an industrial magnate: he sold readily to his new neighbours and in 1879 invested the proceeds in Cottle Wolly, a major sheep and cattle station near Crookwell, renaming it Lake Edward.

The major decisions implemented by the AKa at Joadja were to build stacks of retorts close to the major mines in Russell's Gully and to establish a refinery on the flat land between the mouth of Russell's Gully and Joadja Creek.

The severe earthquake of 1973 destabilised the mine adits on the escarpment and many of the structures in the valley and brochures from that date onwards were marked 'quake damage' and sensible restrictions were imposed on visitors' movements. In the 1980s Mrs Leonie Knapman, with Miss Lee's co-operation, organised 'Back to Historic Joadja' weekends, sponsored by the Southern Highlands Tourist and Travel Association: the last of these was held as a bicentennial event in March 1988. In the previous year the Royal Australian Historical Society had organised a similar tour for its members. Academics from the University of Sydney and the University of New South Wales visited the valley to record aspects of its industrial archaeology in the 1970s. This contributed to R.I. Jack's chapter on Oil Shale in *Australian Pioneer Technology: Sites and Relics* in 1979 and to Darryl Mead's unpublished PhD thesis at the University of New South Wales on the technology and operation of the New South Wales oil-shale industry up to 1906, but an extensive survey of the history and remains of Joadja was published only in 1988 by Leonie Knapman. Ironically this lavishly illustrated tribute to the industrial period of the valley appeared just as the gate to Joadja was effectively padlocked to the outside world.

The difficulty of access to the valley throughout its history, the privacy understandably sought by recent owners, the tight control over visitors and the avoidance of the problem of tourism in a vulnerable environment have preserved Joadja in a quite remarkable way and all the phases of its use, grazing, oilproduction, orcharding, grazing again and limited tourism are clearly presented in the valley today. But its overwhelming importance is as the only surviving oil-shale site in Australia, or elsewhere, showing full benches of horizontal retorts, a refinery which is an important archaeological site little disturbed since demolition in 1902, dramatically complete evidence of community life, water supply and housing, with as bonus, legible archaeological remains of most aspects of an 1875 incline worked by horse-whim. All this is in one of the most beautiful of land-locked valleys, where kangaroos and wombats are today the only permanent residents.

Historic status sought for Kinmen military tunnel

An historical committee under the Kinmen County government determined on Sunday that it would list the 40-year-old Jincheng Civic Tunnel as an officially designated historic site entitled to special protection.

The Kinmen County Historic Structure Evaluation Committee, headed by Kinmen County Commissioner Li Wo-shi (李沃士), decided at a recent meeting to have the 2,559m tunnel, which was excavated in 1968, and -extensively rebuilt in 1978, -officially recognized as being of historic importance.

It is one of the most significant and longest of the 12 underground military base tunnels, built as defense installations on Kinmen since the late 1950s.

The tunnels bear witness to how Kinmen survived the many Chinese communist strikes against it, including extensive shelling in 1958, and how Kinmen has been transformed from a frontline anti-communist bastion into a tourist attraction in recent years.

The Jincheng Civic Tunnel was opened to the public two years ago after being refurbished.

Located in the center of downtown Jincheng, the tunnel connects Kinmen County Hall, Kinmen Bus Station, Kinmen Post Office, the Kinmen Branch of

the Land Bank of Taiwan, the Chinese Nationalist Party's (KMT) Kinmen Chapter, an elementary school and Kinmen Senior High School.

The safety of the wartime tunnel, however, has been called into question in recent months after a property developer began building a 10-story building above the underground fortification.

"We will work out measures to ensure the landowners' rights, as well as protect the historic site," Li said.

If designated as an official historic site, the Jincheng Civic Tunnel will be the 45th protected historic site on the island and the first tunnel to be listed, the county government's Cultural Affairs Bureau said.

Historic tunnels of The Hook

Tunnels which were dug in competition on the Hook by the Welsh {NS} {55 Fed Sqn} and the NZ Maoris {12 Fd Sqn} into the back of the Hook. These tunnels were built in accordance with the RE Field Manuals that seem to have been developed from WW1 experiences.

55 Sqn dug 6 crawl tunnels as part of the communication trenches -up on the higher part & top of the Hook which was a ridge. There were at least one or maybe two of these tunnels which led to machine gun posts facing directly at the enemy. The 184ft tunnel dug to protect Div HQs in July 1952 — after Op Commando to seize the Jamison Line which was a line of hills held until the Armistice. Div HQ was just south of the Imjin River in the second line of defence {Wyoming Line} and north of the third line of defence {Kansas Line}.

The Hook — Korean War 1952–1953

In late July 1952, after warnings that the Chinese Air Force might become active and might use atomic weapons it was decided to make the Divisional HQ bombproof. A tunnel 184ft long was driven through the hill under the HQ by 55 Field Squadron RE in 22 days; working in shifts, and starting at both ends, 2 chambers each 18ft x 19ft were prepared with provision to break out other chambers; the tunnel was timbered throughout.

Towards the end of October 1952 the 1 Commonwealth Division took over additional area on its left flank. This new area contained a feature that later became famous as the Hook position and whilst it was held by a US Marine Corps battalion had suffered much damage.

The Black Watch, who took over the position, immediately requested engineer assistance to repair the bunkers and communication trenches. 55 Field Squadron RE was allocated the task of putting the position right which also required an extra 44 bunkers and 6 crawl tunnels for section strong holds to be dug.

'The Hook' depicting the men of 55 Field Squadron RE repairing the defences one night in April/May 1953 after a period of heavy shelling. (Painting: T Cuneo)

Cut and cover trenches were built with concrete lintels over observation posts (OPs) and medium machine gun (MMG) positions as an alternative to tunnels.

To dig the tunnels teams worked in shifts and each shift advanced about 3ft per day. Pickets were placed every 3ft to secure to Square Mesh Track (SMT) to the rock wall sides of the main communication trenches. On the other trenches combinations of SMT and hessian, cellular fencing and CGI revetting were used. Reinforced concrete beams were used to put over the trenches so that they could withstand heavy shelling.

On another feature, Hill 355, in the Divisional area 12 Field Squadron carried out a similar programme of repairs.

In April 1953 the Chinese increased their intensity of their onslaught on the Hook, but the position withstood and the engineers repaired it each night. The final major attack on the Hook was made on 28 May 1953.

Sapper tasks included preparing shellproof fighting bunkers and machine gun posts with shellproof lintels.

200-year-old tunnel found in Mumbai

An ancient tunnel dating back 200 years was discovered on the premises of the General Post Office (GPO) at CST in Mumbai in October 2010.

The historic structure was unearthed by workers of the General Post Office (GPO) in its premises near South Mumbai's Chhatrapati Shivaji Terminus. "Since decades the flag-hoisting ceremony is conducted at this spot but we never knew about the tunnel," postal services director Abha Singh said. "The lid was believed to be a drainage cover until a few workers lifted it and found ladders running down."

A newspaper reporter learnt about the place and informed the GPO authorities to check it. After digging deeper into the spot which looked like a cement structure which was covered with a lid, the passageway was found.

According to the GPO workers, the tunnel resembles a 'dark cave-like structure' and has a vast hall, thick walls, pillars, muddy floor and unidentified plants with pretty flowers among other things. "We will visit the site and study if the place has any heritage value or historical background," Mumbai Heritage Committee chairman Dinesh Afzalpurkar said.

The GPO in Mumbai is one of the city's most famous landmarks

Some reports say there is a possibility of it being an escape route connected to another tunnel. Three ways out, with covers, have been found so far in the garden.

Director of Postal Services Abha Singh said that the covers had holes in them, indicating they were not conventional manholes."It was perhaps to allow air to pass so that people did not suffocate. If it was just for sewage then the lids would be closed completely," he said.

Mr Rehman said that the original drawings for the building were not available in India. Officials say they could be in the UK — the former colonial power.

"Maybe if we could access the original plan we may be able to find out if there are more — and what purpose these structures served."

Officials say that if the history of the tunnel is confirmed, they could try to win a higher heritage grade so the structure could become a tourist attraction.

"Unless an architect or engineer investigates further it will be difficult to say if it is a huge basement or a tunnel," historian Sharada Dwivedi said. "Tunnels were common to forts — whether it was Maratha, Mughal or British forts."

The old Elbe tunnel

The old Elbe tunnel, opened in 1911, is one of the oldest still operating tunnels in Europe. Open to traffic and pedestrians, it connects the inner city of Hamburg at Landungsbrücken (north entrance) with the shipyards at Steinwerder (south entrance). The south side of the Elbe river offers a spectacular view of Hamburg's cityscape that is most impressive when it's lit at night.

The tunnel is 24 m below the surface The 426 m long tunnel is glazed with ceramic tiled reliefs depicting maritime motifs on the walls.

Recently, this historic landmark has inspired various annual projects: For the past 8 years, 100 Marathon

Club Deutschland has been organizing the Elbtunnel marathon every last Sunday in January. Since 2007, ElbArt has been inviting local artists to exhibit their work in the tunnel in the summertime.

THE OLD VIC TUNNELS

In February 2010, The Old Vic acquired this new performance space beneath Waterloo Station from BRB (Residuary) formerly British Rail. This unique venue showcases productions, performances and installations and will continue to be home to a series of innovative and surprising arts events throughout 2010 and into 2011.

This year The Old Vic Tunnels opened as The Lambeth Palace, an underground cinema built to screen the UK premier of Banksy's film *Exit through the Gift Shop*, followed by the first major theatre production in the space — *Ditch*, by Beth Steel, a collaboration with High Tide. This was followed closely by *Aftermath*, as part of the LIFT Festival and over the last few months, a number of varied events have taken place. These include *SlapDash*, a three day festival of Improvisation and Alan Moore, the graphic comic genius behind *V for Vendetta*, *League of Extraordinary Gentleman*, and *The Watchmen* read his new short story *Unearthing* to images supported by a live band. The first music concert in the venue featured Villagers' who received a Mercury prize for their single *Becoming a Jacka*. Not forgetting the Tunnels volunteers who produced an extravaganza of cross-art collaboration, the sold-out *Dark Carnival: Notes from Underground.* Most recently, the Tunnels have been home to the British premiere of Scorched, a play by award-winning playwright Wajdi Mouawad.

THE VOLUNTEERS SCHEME

The Old Vic Tunnels Volunteer Scheme offers fantastic opportunities for young people to be part of this innovative and diverse arts venue. Supporting a large group of 16-25 year olds working as Producers, Marketers, Technicians and Front of House Staff, this scheme has produced sell-out shows, such as *Dark Carnival*, and continues to offer brilliant assistance to all who come to the Tunnels. We have had over 300 young people taking part in the scheme so far — expanding their skill set and becoming part of a burgeoning London community — a number which has exceeded all expectations

This unique venue showcases productions, performances and installations and will continue to be home to a series of innovative and surprising arts events throughout 2010 and into 2011.

Rove Tunnel

Between 1911 and 1916, the Rove Tunnel was built to link the Marseille Harbor to the Rhone River. But it wasn't until 1926, after twenty years of work and a World War, that the tunnel was finally opened for use, surviving a little under 40 years before collapsing in 1963.

The longest canal tunnel in the world, the Rove Tunnel passes through Berre Lake (adjacent to the Mediterranean to the west of Marseille) and Martigues (a commune in the southeastern part of France, to the northwest of Marseille), and stretches about 4.5 miles in length and 72 feet in width, which, before it was closed to public use, enabled about two ships to cross inside.

Although it has been abandoned for years, a project has been launched to bring this tunnel back to life by using it as a salty water supply for the Berre Lake, which is slowly drying.

Clayton Tunnel (built in 1840)

Most Southern tunnels have relatively plain portals, but Clayton Tunnel, on the Brighton line, is a joyous exception. Perhaps because it was easily seen from the old Brighton Road, it was built to impress.

Constructed of yellow brick, with Caen stone detailing, it resembles the entrance to a fortress, with battlemented, hexagonal towers either side of the portal. Flanking walls are terminated by smaller, square turrets. The structure even has arrow slits, as though archers were waiting to repel Brighton-bound excursionists. The tunnel mouth itself is made more impressive by having a large outer arch set forward of a smaller one. Both arches have stone voussoirs. Quite incongruously, a domestic cottage crouches between the towers over the tunnel mouth. This may have been built to accommodate the attendant who supervised the gas lighting in the tunnel. In the early days the London & Brighton Railway whitewashed the interiors of its tunnels and lit them with gas jets. The tunnel portal was renovated by Railtrack in 1995. Movement in the main towers required careful demolition of the upper parts, followed by rebuilding using the original material. The brickwork was lightly cleaned and surrounding vegetation removed, so the tunnel is again clearly visible from the road bridge to the north. In complete contrast, the southern portal, which is not easily seen, is quite plain.

Charlton tunnel cave — a rail tragedy waiting to happen

In 1849 a cave in chalk was discovered underneath the level of the railway line while excavating one of the tunnels underneath Maryon Wilson Park (between Charlton and Woolwich Dockyard stations). The railway passes across the entire breadth of one of the chambers, and the only work that was done to support the railway was described as "shoring up a part of the roof of one of the chambers." The current condition of that shoring is unknown, as is the exact location of the cave. Dozens of trains use this line every day, passing through the two short tunnels at up to 40mph.

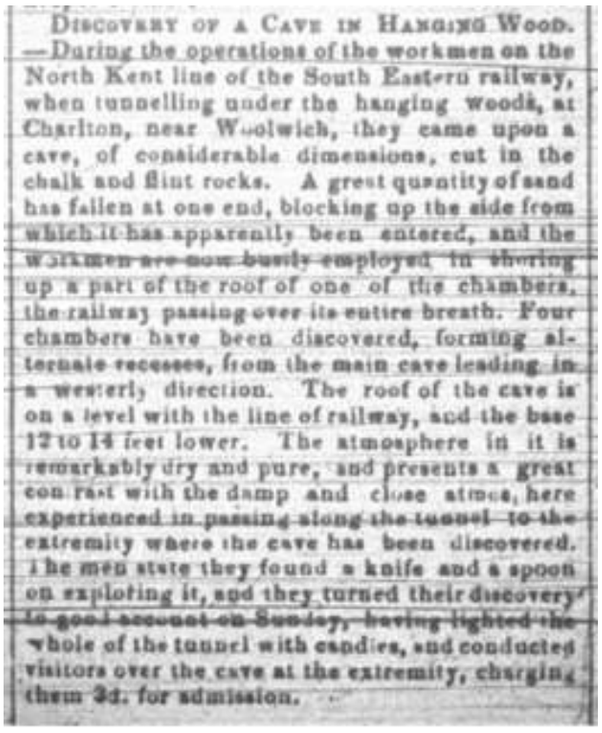
The western tunnel is Charlton Lane Tunnel 154 yards. The eastern tunnel is Mount Street Tunnel 121 yards. It is not known which tunnel the cave is located in.

The article describing the cave appeared in the Kentish Mercury on Saturday March 24th 1849.

Here is an exact transcript:

DISCOVERY OF A CAVE IN HANGING WOOD. – During the operations of the workmen on the North Kent line of the South Eastern railway, when tunnelling under the hanging woods, at Charlton, near Woolwich, they came upon a cave, of considerable dimensions, cut in the chalk and flint rocks. A great quantity of sand has fallen at one end, blocking up the side from which it has apparently been entered, and the workmen are now busily employed in shoring up a part of the roof of one of the chambers, the railway passing over its entire breath. Four chambers have been discovered, forming alternate recesses, from the main cave leading in a westerly direction. The roof of the cave is on a level with the line of railway, and the base 12 to 14 feet lower. The atmosphere in it is remarkably dry and pure, and presents a great contrast with the damp and close atmosphere experienced in passing along the tunnel to the extremity where the cave has been discovered. The men state they found a knife and a spoon on exploring it, and they turned their discovery to good account on Sunday, having lighted the whole of the tunnel with candles, and conducted visitors over the cave at the extremity, charging them 3d. for admission.

The railway tunnels in about 1880



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Charlton Lane tunnel

Mount Street tunnel

Mexico uses robot to explore ancient tunnel

The first robotic exploration of a pre-Hispanic ruin in Mexico has revealed that a 2,000-year-old tunnel under a temple at the famed Teotihuacan ruins has a perfectly carved arch roof and appears stable enough to enter, archaeologists announced Wednesday.

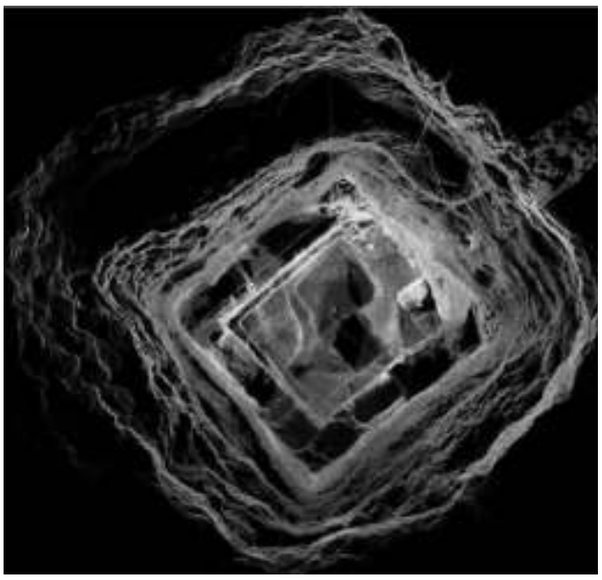
Archaeologists lowered the remote-controlled, camera-equipped vehicle into the 12-foot-wide (4-meter) corridor and sent wheeling through it to see if it was safe for researchers to enter. The one-foot (30-cm) wide robot was called "Tlaloque 1" after the Aztec rain god.

The grainy footage shot by the robot was presented Wednesday by Mexico's National Institute of Anthropology and History. It shows a narrow, open space left after the tunnel was intentionally closed off between A.D. 200 and 250 and filled with debris nearly to the roof.

Archaeologist Sergio Gomez says the footage showed the arched-roof tunnel was an example of sophisticated work by the ancient inhabitants of Teotihuacan, which is located just north of modern Mexico City.

"All of the passage, more than 100 meters (yards) long was excavated in the rock perfectly, and in some places you can even see the marks of the tools the people of Teotihuacan used to make it," said Gomez.

Well-worked blocks and a smoothly-arched ceiling showed the tunnel was not natural, but rather a man-made structure that researchers believe lead to possible burial chambers.



Researchers hope to clear the debris blocking the tunnel's mouth and enter passageway by late November or early December.

Robots have been used before in Egypt. In 2002, a robotic vehicle was used to discover a hidden door and chamber in the Great Pyramid built by the pharaoh Khufu more than 4,000 years ago.

But the INAH, as Mexico's archaeology agency is known, said it appeared to be the first robotic exploration in Mexico and probably in the Americas.

After excavating a vertical shaft that leads to the tunnel entrance, the mouth of the passageway was discovered in July. Ground-penetrating scanner images showed that the passageway lies 40 feet (12 meters) below the surface, and runs beneath the Temple of Quetzacoatl, in the central ceremonial area of the ruins.

The scanner images appear to show chambers that branch off the tunnel and archaeologists think they may hold the tombs of some of the ancient city's early rulers.

Experts say a tomb discovery would be significant because the social structure of Teotihuacan remains a mystery after nearly 100 years of archaeological exploration at the site, which is best known for the towering Pyramids of the Moon and the Sun.

No depiction of a ruler, or the tomb of a monarch, has ever been found, setting the metropolis apart from other pre-Hispanic cultures that deified their rulers.

Vertical excavations begun in 2009 to reach the mouth of the tunnel suggest it was a ruler's tomb, Gomez said. Rich offerings were tossed into the tunnel at the moment it was closed up, including almost 50,000 objects of jade, stone,

shell and pottery, including ceramic beakers of a kind never found before at the site.

The complex of pyramids, plazas, temples and avenues was once the center of a city of more than 100,000 inhabitants and may have been the largest and most influential city in pre-Hispanic North America at the time.

But nearly 2,500 years after the city was founded — and about 2,100 years after the Teotihuacan culture began to flourish there — the identity of its rulers remains a mystery. The city was abandoned by the time the Aztecs arrived in the area in the 1300s and gave it the name "Teotihuacan," which means "the place where men become gods."

The scanner images appear to show chambers that branch off the tunnel and archaeologists think they may hold the tombs of some of the ancient city's early rulers.

Medieval tunnel found at Lincoln Castle

Archaeologists excavating the ground level of the bailey at the center of Lincoln Castle have uncovered a previously unknown tunnel connecting to a circular structure. The dig is in preparation for the future construction of a wheelchair-accessible elevator that would bring visitors up to the castle walls.

The find is exciting not just because it might well have been originally constructed as a secret passageway, which is inherently awesome, but because it's the only medieval structure surviving inside the castle bailey. The newly-discovered structure has been provisionally dated to the 12th century, which makes it one of the first stone buildings in the castle.

Lincoln Castle was built by William the Conqueror just 2 years after the conquest to consolidate his power. In 1068 it was just a wooden keep, but it was later replaced by a stone one. The castle has been built on and over repeatedly since then, so finding original stone structures is a major coup.

County archaeologist Beryl Lott described it as an exciting and unique discovery. She said: "There are no other known surviving remains of medieval structures within the castle bailey. These excavations have discovered the remains of a substantial stone building with a circular interior, possibly the remains of a stairwell or room below the current ground level of the castle bailey. The room is accessed by a doorway, which leads into a tunnel in the direction of the central bailey area."

Lincoln Castle saw a lot of exciting action in the 12th century, most famously the battle between King Stephen and Empress Matilda in 1141. If you've read Ken Follett's Pillars of the Earth, watched the sadly inferior TV series based thereon, or read the Cadfael book Dead Man's Ransom, the First Battle of Lincoln featured prominently.

Stephen besieged Lincoln Castle where Matilda was holed up, but just when it looked like she was done for, her half-brother Robert of Gloucester charged in like the cavalry and won the day. Stephen was captured and Matilda garnered herself a short-lived spell — from February to June — on the throne of England. Who knows but Matilda might have taken cover in that passageway before her half-brother's forces came to save her bacon.

Jacob Associates announces Australasian expansion

Jacobs Associates is excited to announce the opening of its second Australasian office in Auckland, New Zealand. Auckland is New Zealand's largest city and is only a three-hour flight from the firm's Melbourne office. The office opened in October and will support our efforts on Watercare's Central Interceptor and various projects for the New Zealand Transport Agency, including the Waterview Connection highway tunnel project.

The firm has a history of working in New Zealand that dates back to the founding of Jacobs Associates in 1954. In fact, one of the firm's first projects (job #7) was a consulting assignment for Fletcher Construction on diversion tunnels for the Ohakuri Dam on the North Island. Other notable assignments in New Zealand include dispute resolution on the Clyde Dam (1986), constructability review/cost estimating for the Waihi Gold Mine, and a tunnel feasibility study for the West Valley Sewer Project in Wellington (1995).

A significant move for Jacobs Associates, this expansion will help the firm better provide tunnel and underground engineering for hydroelectric water supply, wastewater, rail, highway, and other transportation projects in the New Zealand market, while strengthening the firm's local presence and commitment to its ongoing projects.

Jacobs Associates provides practical, cost-effective, and innovative solutions for difficult underground projects and excels in the water, wastewater, and transportation sectors. With an emphasis on tunnels and shafts, we offer a full range of design and construction management capabilities.

We also offer the broader heavy civil construction industry a robust package of claims and dispute resolution services. Jacobs Associates is an award-winning firm with offices in San Francisco, Seattle, Portland, Pasadena, San Diego, Boston, New York, Melbourne, and Auckland. www.jacobssf.com

ATS New Zealand Chapter Report

Do you remember AUCTA? Yes, the old name before the huge decision to expand horizons and meet the needs of the future on a regional basis. It is all of 5 years ago that the initiation of joint activities between New Zealand and Australia in the tunnelling field commenced, with a decision in principle affirmed at the Executive Committee meeting held on the Sunday before the 12th triennial conference in Brisbane in 2005.

Capturing the region in its name, the Australasian Tunnelling Society [ATS] became the encompassing technical society for all those dedicated to the development of the underground in Australia and New Zealand. New Zealand became the 5th Chapter, joining NSW, Victoria, Queensland and Western Australia. By 2007, the fledgling Chapter had a little muscle on its skeleton and a target was set to host the 14th Triennial Tunnelling Conference in Auckland NZ. This was confirmed as viable in late 2009, and in March 2011, NZ will host the regions' tunnelling fraternity.

The triennial conference has a reputation of being the tunnelling showcase event and the 14th event will, we believe, confirm this reputation as correct. With three excellent keynote speakers and three days of interaction; all who attend should leave informed on the state-of-the-art down under.

The conference has consumed much of the energy of the petit organising committee. It would not have happened without the labours of Rory Bishop, John Cooper, Keith Dickson, Tom Ireland and last but notably not least, Bill Newns. The logistics and costs involved have elevated the requirements for arranging such conferences to a point that is, frankly, quite demanding on those volunteers who get it all done. A full audience in Auckland, including your presence, will make all the hard work worthwhile! Wise committees include those with specialist skills such as AUSIMM Conference Convenors; they have been our valued partnering organisers.

The conference organisation consumed much of the year and especially the second half. However, we still had two well attended technical evenings in 2010. During the first quarter, the local tunnelling fraternity were entertained by Dr Ralf Winterberg (Maccafferri), who spoke on the use of steel fibre reinforcement in tunnel segment design. There was excellent networking both before and after the talk, which was sponsored by Maccafferri. The quality of the talk both in terms of content and visuals was supreme.

Towards the mid year, Tom Ireland [Aurecon] gave a presentation on the construction of the Hindhead Tunnel in the UK. Discussions on shotcreting and waterproofing during the question session were vibrant. The visuals Tom used in the presentation were excellent and provided good detail of some aspects covered.

We'd like to see you in Auckland 7 — 10 March 2011; to make it easy, here is a link to the site for conference registration: www.atstunnellingconference2011.com

AUSTRALASIAN TUNNELLING SOCIETY

AusIMM THE MINERALS INSTITUTE

IPENZ ENGINEERS NEW ZEALAND

ENGINEERS AUSTRALIA

14th AUSTRALASIAN TUNNELLING CONFERENCE

First time in New Zealand – a unique opportunity for all interested in the development of the Underground Space

When: 8th to 10th March, 2011

Where: Sky City Conference Centre

Make sure that you attend the pre-eminent tunnelling colloquium for Australasia. A truly European flair will be enjoyed through the participation of Professor Giovanni Barla, Turin Polytechnic University, who is one of the keynote speakers at the conference. Giovanni never fails to infuse his audience with his enthusiasm and love for underground soil/rock mechanics and we look forward to his address. Giovanni will also lead a pre-conference short course; an opportunity for immersion into European thinking and approaches.

Many advances have been achieved across the Asian scene and Alan Morris, Project Manager for the XRL Tunnels, MTR Corporation Ltd, Hong Kong will provide an overview of these while also outlining his views on where our industry finds itself in terms of technical developments.

Our third keynote speaker, Professor Arnold Dix, Chairman of the ITA Contractual Practices group and Australian delegate to PIARC in tunnel ventilation, safety and environment will address operational issues in particular in vehicular tunnels.

CLICK TO VISIT THE CONFERENCE WEBSITE AND REGISTER ONLINE
www.atstunnellingconference2011.com

Pre-Conference half day course on Face Stability Analysis and Support in Tunnelling by Professor Giovanni Barla, Turin Polytechnic University on Monday 7th March 2011.

Time: 1.30pm – 6.00 pm

ENQUIRIES

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Bill Newns,
Ph: 523 7018
Email: newnsb@ap.aurecongroup.com

ATS Brisbane Group Report

Tunnelling activity continued at intense levels in Brisbane through 2010. The first of the TransApex tunnels, the Clem7 opened in March, the second project Airport Link Northern Busway passed the halfway mark and a contract award for the Northern Link project occurred in December. Combined, those 3 tunnelling projects have a contract value around $8B. The next project is expected to be the $8B Cross River Rail project where detailed engineering studies are in progress and a go-ahead is anticipated late in 2011.

Our monthly technical sessions continue to attract audiences of between 80 and 120.

Date	Title	Speaker	Sponsor
March 2011	Melbourne's Utility Tunnels	E Stamatopoulos, John Holland	John Holland Tunnelling
April 2011	Constructing the Bogong Hydro Power Project	Brendan Hayes McConnell Dowell	McConnell Dowell
May 2010	City West Cable Tunnel, Sydney	Christian D'Hondt, Thiess	Thiess
June 2010	State of the Art Tunnel Formwork Systems	Aldo Ceresola, CEO of Ceresola	Ceresola
July 2010	Geological Considerations for TBM selection	Karin Bäppler, Herrenknecht	Herrenknecht
July 2010	The Electrics of the Clem7 Tunnel	Bryan Cheetham, United Group	ATS/ITEE
September 2010	Geological Constraints and Geotechnical Issues in Mechanised Tunnelling	Dr Paul Marinos, the 2010 Jahns Distinguished Lecturer	Jacobs Associates & BOSFA
September 2010	Geotechnical and Contractual Interaction	Prof Arnold Dix, Chairman, ITA Contractual Practices Group	Bamser
October 2010	The Crossrail Project, UK	Prof Arnold Dix, Chairman, ITA Contractual Practices	Bamser
December 2010	Tunnel Waterproofing	Jason Palise, Bluey Technologies	Bluey Technologies

In addition to the technical sessions, our local committee held two breakfast meetings and also published three newsletters. Engineers Australia Queensland continues to support us by providing a superb venue for our technical sessions and also a videostreaming service via their EAQ website.

The inaugural ATS Industry Golf Day held in Brisbane in September was a great success. 52 players teed off in the Ambrose event at St Lucia Golf Links which raised $6,000 for the Royal Brisbane and Women's Hospital Foundation. Our local ATS committee comprises:

Andrew Day, Thiess (Chairman)	Alex DeAboitiz, City North Infrastructure	Charles MacDonald, BrisConnections
Scott Keniston, Bamser (Secretary)	Andrea Edney, Leighton	Jeremy Kruger, TJH
Alan Robertson, AusRocks (Treasurer)	Doug Maconochie, Parsons Brinckerhoff	Simon Strong, Herrenknecht
Warren Mahoney, BASF	Paul Wallis, Arup	
Craig Roberts, BOSFA	Matthew Norbert, GHD	

Andrew Day
Chairman, Brsbane Group

ATS Melbourne Group Report

The Melbourne Group finished the last quarter of 2010 with two technical sessions. The planned session on the state of underground mining has been deferred until the new year.

14th October 2010
"Geological Considerations for TBM Selection", presented by Dr Karin Bappler from Herrenknecht.

23rd November 2010
An interactive session titled " Who is Responsible for Ground Support", with presentations by Craig Farr from John Holland Tunnelling and Richard King from Coffey and chaired by Harry Asche from Aurecon.

The continuing trend of well attended sessions is most encouraging to the committee. The interactive session was a new initiative for the Group and similar sessions along these lines are planned for the future.

The Melbourne Group AGM was also conducted at the November session. The election of committee members for 2011 saw an addition of three new members and office bearers were appointed at the next committee meeting. The new committee comprises Ed Taylor (Chair), Tony Bennett (Secretary), Bruce Grant (Treasurer), Nigel Sugden and Mo Moradalizadeh (Program Coordinators), Malcolm Dixon, Chris Boyd, Andrew Kindred, Wouter Hartman, John Main and Emma Reiners.

Technical sessions conducted throughout 2011 were fully sponsored and we acknowledge the support from McConnell Dowell, John Holland, Baulderstone, Mott MacDonald, Herrenknecht and Geohart.

The program currently planned for the first quarter of 2011 is as follows.

February 2011
State of Underground Mining in Victoria, Tasmania and South Australia

March 2011
Metro Systems

April 2011
Melbourne Main Sewer Replacement

There are tentative plans for an additional 6 sessions for the remainder of the year.

Ed Taylor
Chair, Melbourne Group

ATS Sydney Group Report

It has been a relatively quiet year on the tunnelling front in Sydney but hopefully the likely changing state political landscape may produce some much needed investment in major infrastructure projects.

Our first scheduled technical session of the year got off to an unfortunate start when the presenter Alan Ross (BOSFA) suffered an attack by a spider in New Zealand and we had to cancel at the last minute. However, the presentation on Steel Fibre Reinforced Concrete was re-scheduled and presented on 21 April 2010.

The following technical sessions were hosted by the Sydney Group:

- 16th June Florence and Matilda (TBMs CLEM7 Tunnel) presented by Michael Huber.
- 18th August Remote Monitoring Systems for Tunnel Projects in CBD Areas presented by SolData.
- 20th October Tunnel Power Supplies, Design and Installation, presented by Mark Apthorpe (Rutherford International).
- 8th December *"The History of Australian Tunnelling"*, presented by David Lees Editor ATS Journal (GFWAust).

With regard to the October presentation it was pleasing to see a number of both new and young faces.

The ATS National Committee is currently organising a bid for Sydney to host the World Tunnelling Congress conference in April 2014. The formal bid will be lodged at the May 2011 WTC conference in Helsinki. An organising committee has been set up and is chaired by Garry Ash.

ATS WA Chapter Report

Since last report in September 2010, the WA Chapter held or is planning the following technical sessions:

10 September: Minibus tour to Binningup Desal 2 site approx 1.5 hrs south of Perth and inspection of TBM pipejack tunnels for ocean intake and outfall tunnels and onshore plant site.

26 November 2010: Tour of Fremantle Prison Heritage tunnel system

The tour went really well until a late arrival had to do the obligatory breathalyser test before descending into the tunnels under the prison and into the boats, to paddle through the water filled tunnels. He had been to an office Christmas party and blew 0.01% alcohol. Luckily this was under the "tunnel limit" and the tour proceeded without mishap. An earlier tour had the first ever capsize in the tunnels spilling boat and crew into the icy water 20m underneath the prison. Ouch! The tour was finished off with the obligatory few coldies at Little Creatures Brewery, Fremantle Fishing Boat Harbour where a several additional committee and other members joined the tour group for the debriefing session.

10 February 2011: Planning for a Rail Link to Perth Airport

The Public Transport Authority of Western Australia **Perth City Link Rail Project** involves lowering the Fremantle rail lines into cut and cover tunnel above the existing Joondalup line bored tunnels, eventually to be followed by lowering of the Wellington Street Bus Station underground to enable redevelopment of the Perth Rail Yard land for public open space, residential and commercial towers and other civic developments. The first stage of the project, lowering the rail lines, is in the Alliance tendering mode, with two selected consortia (Brookfield Multiplex-Laing O'Rourke and John Holland-GHD) having submitted their competitive TOCs on 23 December 2010. The TOCs are under evaluation by the PTA, with the selected Alliance consortium due to be announced in March 2011. Project completion is scheduled for 2014.

The Desal 2 Project at Binningup, about 1.5 hours' drive south of Perth is well underway. It will supply water to Perth, as well as the nearby regional city of Bunbury. It is designed to initially deliver 50 gigalitres of potable water per year or 20% of Perth's requirements. Capacity may be increased to 100 gigalitres/year at a future date. The project will deliver potable water into the South West Integrated System via a 30 km 1.3m diameter pipeline to a storage facility near Harvey. It is expected to be operational in 2011.

The site is located at about 1.2km from the coast with most of the plant situated in a disused limestone quarry. The two intake and one outlet pipelines from the plant to the beach and extending about 500m under the ocean were constructed using two tunnel boring machines and pipejacking technology to cover a distance of about 900m for each tunnel. The project is being undertaken by the Southern SeaWater Alliance and the Water Corporation (SSJV) and the tunnelling work was undertaken by Zueblin Australia Pty Ltd.

The WA Chapter Committee comprises 6 members and meets monthly. The Chapter has over 70 individual members plus 5 company memberships registered in WA. Keep an eye on the ATS website for future event details.

Eric Hudson-Smith
WA Chapter Chair

14th Australasian Tunnelling Conference 2011

8–10 March 2011, SKYCITY, Auckland, NZ

Development of Underground Space

Gold Sponsors: John Holland | McConnell Dowell

THE TECHNICAL PROGRAM

The Conference Technical Program has now been released! Click here to view the three day program which offers you more choice with dual sessions incorporating the following themes:

- Ground Support
- Hydropower
- Excavation
- Geotechnical
- Fire Life & Safety and
- Environmental Challenges & Risk.

The program will also feature the below highly regarded International Keynote presentations and with fantastic networking opportunities this Conference should not be missed!

KEYNOTE PRESENTATIONS

- Open Issues in TBM Excavation of Deep Tunnels
  Professor Giovanni Barla, Department of Structural and Geotechnical Engineering, Turin Polytechnic University
- Fire Suppression Systems — Protection for People, Concrete or Profits
  Arnold Dix, Professor, International Tunnelling Insurance Group
- XRL: Challenges of Tunnelling through Hong Kong and into Mainland China
  Alan Morris, Project Manager, for the XRL Tunnels, MTR Corporation Limited, Hong Kong

OPTIONAL SHORT COURSE

Face Stability Analysis and Support in Tunnelling — Monday 7 March 2011

Presented by Giovanni Barla this half day workshop will comprise of 6 lectures covering:

- Full face excavation in conventional tunnelling.
- Face and heading stability analysis by empirical and analytical methods.
- Face and heading stability analysis by numerical methods.
- Full face excavation of large size tunnels in heterogeneous rock mass near the ground surface.
- Full face excavation and reinforcement coupled with yield control systems to cope with squeezing conditions.
- Case studies of TBM tunnels with face stability problems.

THE EXHIBITION

With a sell out Exhibition, this Conference is set to be a huge success! Exhibitors on show at this year's event include:

EXHIBITORS

- AECOM
- Ampcontrol Pty Ltd
- Aquasys Technik GMBH
- Aurecon
- BASF Construction Chemicals Australia
- Beck Engineering
- BOSFA Pty Ltd
- C R Kennedy Survey Solutions
- Durham Geo Slope Indicator
- Dywidag-Systems International (DSI)
- Elasto Plastic Concrete
- Golder Associates
- Halcrow Pty Ltd
- Hard Metals Industries
- Herrenknecht
- Itasca Australia
- ITM — Soil Pty Ltd
- Jacobs Associates
- John Holland
- Liebherr
- McConnell Dowell
- Mining Equipment Ltd
- Parsons Brinckerhoff
- Phoenix DG
- Sandvik Mining and Construction
- Sika (NZ) Ltd
- Stratacrete
- Tam International Australia Pty Ltd
- Team Mixing Technologies Inc
- The Robbins Company
- Thiess Tunnelling
- Tunnel & Mining New Zealand Limited
- Xypex Australia

CONFERENCE TOURS

- **Wine and Waiheke** *Expression of Interest only*
  Sunday 6 March 2010
- **State Highway 1 Victoria Park Tunnel, Auckland**
  Monday 7 March 2011

ASSOCIATION INTERNATIONALE DES TUNNELS ET DE L'ESPACE SOUTERRAIN
AITES
ITA
INTERNATIONAL TUNNELLING AND UNDERGROUND SPACE ASSOCIATION

Muir Wood Lecture

In 2009 ITA has decided to establish a "Muir Wood Lecture" to be delivered once a year during the World Tunnel Congress (WTC).

The first Muir Wood Lecture has been delivered by Professor Einar Broch, former ITA President, in Vancouver during WTC 2010.

The second lecture will be held by Professor Robert Mayr, who has tenure of the Civil Engineering chair at Cambridge University (UK).

We are now in the process of selecting the lecturer for the third Muir Wood lecture to take place in Bangkok in May 2012. The name of this lecturer will be announced in Helsinki.

New look for ITA website

ITA — The International Tunnelling Association — has recently revamped its website (www.ita-aites.org) which is now divided into Corporate and Information sections. The Corporate section features information for members and affiliates of the Association, as well as technical information for tunnelling professionals; while the Information section contains information for the general public, owners and students.

Although designed to be more general, the Information section highlights the environmental, social and economic reasons for supporting underground construction. Also, sub-sections will cover tunnel design, construction and operational principles, as well as the various uses of underground space. It will all be complemented by case studies, videos and picture galleries. According to ITA, the site has 7,000 unique visitors/month and around 175,000 visits/year.

Lausanne-based ITA was founded in 1974 with a remit to promote the use of underground space within the confines of social needs, environmental concerns and sustainable development. It now boasts 58 member-nations and has formed numerous working groups to foster the global development of training, health and safety, research, contractual practices ant tunnelling techniques, to name but a few. The next ITA-AITES World Tunnel Congress will be held on 21–26 May 2011 in Helsinki, Finland. www.wtc11.org/

ITA COSUF AWARD

The ITA COSUF award is granted annually to students/ young researchers who have recently completed an outstanding research work in theory and / or practice in the area of safety and security of underground facilities.

The winners of the award are selected by the ITA COSUF steering board. The award will be ceremoniously presented and handed over by the chairman of the ITA COSUF at an event of the ITA COSUF. The chairman will outline the reasons for the decision and will honor the winner. The award consists of a certification, a medal and Euro 500 in cash. The award winning work will be published on the ITA COSUF website.

Eligible for the award are those works that are specifically aimed at safety and security of underground facilities in operation, preferably reflecting the interdisciplinarity.

The steering board of the ITA COSUF has outlined the criteria to assess the work of nominated candidates for the ITA COSUF award. The work shall, among other criteria:

- describe new aspects in the area of safety and security in underground facilities
- be completed not more than two years before the time of the nomination
- be of outstanding quality, including clear and concise descriptions of the objectives, the scientific base, the work steps carried out, the results achieved and their relation to the current state of the art etc
- be significant and represent an unique contribution

Nominations for the ITA COSUF award may be deposited at the ITA COSUF steering board or at the ITA secretariat.

You may find more on ITA COSUF on www.ita-aites.org.

OBITUARY

Val Lee

Val was a dear friend to the ATS and was our secretary at Engineers Australia for many years. It is with a sad heart that I have to report her death on 27th January 2011 following a relatively short battle with lung cancer.

Val was one of Engineers Australia's real characters. Val was a complete iconoclast. She broke more rules than have been written. Her language was sometimes rather colourful. She focused only on the important. Details were for obsessive people, something she could never be accused of. She was warm and supportive and unendingly positive in outlook, she was always thinking of others and was passionate and strategic in promoting her causes.

At Engineers Australia she cajoled her Colleges and Technical Societies, and she will remain a legend particularly to the Structural Members, the Tunneling Society and Australian Geomechanics.

In the Canberra community, her work in support of people with cancer will be her lasting legacy.

She was closely supported by family and friends over the last few months, and her spirit never faltered.

Val will be badly missed.

ITA WORKING GROUPS AND COMMITTEES: **REPORTS AND PROJECTS OF ACTIVITY**

1. ITA-COSUF: Chairman: Felix Amberg (Switzerland), Vice-Chairman: Didier Lacroix (France), Tutor: Claude Bérenguier — Report presented by the Chairman:

ITA COSUF has currently 62 members coming from 17 countries. The core of ITA COSUF is composed by the three Activity Groups (AG):

- AG 1: Interaction with European and International activities
- AG 2: Regulation and best practice
- AG 3: Research and new findings

Through these AG's the following activities have been developed in the last 12 months since the General Assembly 2009 in Budapest:

- ITA-COSUF Workshop, 4–5 November, Lyon: "Safety challenges"
- ITA-COSUF sponsored the ISTSS (International Symposium on Tunnel Safety and Security), 15–18, Frankfurt
- three Steering Board and two AG meetings

A special emphasis should be put on the report "Survey of existing regulations and recognised recommendations (rail, metro, and road)", which can be downloaded from the ITA COSUF website.

The ITA — COSUF Award for outstanding activities and to support dedicated work of students within the scope of ITA-COSUF was awarded to B Niemen, the Netherlands.

The next General Assembly will be held in Helsinki at the occasion of the WTC.

2. ITA-CET: Chairman: Andre Assis (Brazil), Vice-chairman: Daniele Peila (Italy), Secretary General: Claude Bérenguier — Report presented by the Chairman:

Membership: 45 members

Board 2010–2013: 6 members: Andre Assis (Brazil), Chairman, Daniele Peila (Italy), Animateur of the WG18, Vice-Chairman, Fulvio Tonon(USA), Robert Galler (Austria), Jian Zhao (Switzerland and Claude Bérenguier (Secretary General).

Data Base for lecturers: The Committee is gathering the Resumes and preferred topics for potential lecturers during the training which are organized by ITA and by ITACET Foundation.

Status of the preparation of the portfolio of the Committee

Workshops and Training Sessions

In addition to the seven already accepted six new proposals were accepted after amendments:

- Monitoring and Control
- Immersed Tunnels
- Utility Tunnels in Cities
- Principles in Tunnel Design
- Tunnel Innovations in Tunnelling
- Underground Space Use.

Three other proposals will be studied later:

- Geo-Investigation.
- Numerical Simulation in Tunnels.
- Maintenance and Repair

Endorsement for Master Courses

- Professional Master Course: proposal from the French Association (AFTES) presented by Michel Deffayet; the ITA endorsement will be pronounced after providing names of lecturers.
- Msc Diploma: discussions on the ITA endorsement are on-going; the decision will be made at the next meeting.

Endorsement for short courses: The principle of this kind of endorsement was accepted providing that the course will not be business oriented and that representatives of ITA will participate to the organization and to the course itself.

On line Courses: The concept was presented by Fulvio Tonon; the principle was accepted with the same conditions than the short courses plus a special request concerning the system of validation of the acquired knowledge by the students.

Programme of the Foundation July 2010–June 2011:

Two-day Training Session — Helsinki: WTC 2011: 20–21 May 2011 "Holistic Approach for Use of Wet Sprayed Concrete for Rock Support".

Other Training Sessions

- Abu Dhabi: Immersed Tunnels — October 2010.
- Bahrain: Utility Tunnels in Cities — Time to be decided.
- Malaysia: Principles of Tunnel Design — 26–27 February 2011.
- Thailand: Tunnel Design, Instrumentation and Risk Management: November 2010.
- India: Health and Safety and one another topic — to be confirmed.
- Austria: Numerical Simulation — Time to be decided

Seminars

- Argentina: Construction Methods for Tunnelling: 22-23 October 2010

- Russia (Sochi): Holistic Approach for Modern Conventional Tunnelling — October 2010.
- Singapore or Korea or?: Innovation in Tunnelling — Place and Time to be decided
- Colombia or Peru: Topic and Time to be decided

3. WG 2 — Research: Animator: Eric Leca (France), Vice-Animator: Chung Sik Yoo (South Korea), Tutor: Soren Eskesen (Denmark) — Report presented by Barry New:

The group met on Sunday, May 16th. The meeting was attended by 18 participants representing 12 member nations; China, Czech Republic, Denmark, France, Japan, Italy, Netherlands, Spain, Thailand, United Kingdom. USA.

The activity of WG 2 since the Budapest meeting has focused on the preparation of three reference documents which relate to

- "Monitoring and Control for tunnelling projects"
- "Strategy for Site Investigations of underground works"
- "Risk Management for tunnelling and underground work"

The recommendation of "Monitoring and Control for tunnelling projects" has since the Budapest meeting been issued to the Executive Council and reviewed by the Executive Committee. Comments have been partly received. The document is currently being updated for re-issue to the ExCo.

The work on the document "Strategy for Site Investigations of Underground Works" Works was progressed and an updated version will be circulated shortly after the Vancouver meeting.

National site investigation documents have been collected. Member nations are asked to provide project examples. It is expected that a final draft can be discussed at the Helsinki meeting. WG 2 liaises with ISRM on a joint initiative on the site investigation document. On the risk management subject a lecture was presented at the ITA-CET pre-conference training course. An outline of the supplementary document to the 2004 "Guideline on Tunnelling Risk Management" was discussed. A summary of collected case histories of projects where the risk management procedures have been successfully implemented is being produced and will be included.

An outline document on "Assessment to pipeline damage associated with tunnelling" was presented and debated by the group for future action. It was agreed to progress this subject. Also presented was a draft paper on "Fibre Reinforced Concrete for segmental tunnel lining". The authors were requested to change the document into a guideline/recommendation seeking input from other member nations.

4. WG 3 — Contractual Practices: Animator: Arnold Dix (Australia), Vice-Animator: Martin Smith (Switzerland), Tutor: Martin Knights — Report presented by the Tutor: The project of the group over the last two or three years is to review the ITA contractual practices and publications and make them applicable to contemporary life today. They have eleven member states who are active members of the working group.

In furtherance to the ITA's commitment to promoting the development of underground space they produced an issues framework which exposes the issues critical to successful underground project contracting and everybody is urged to consider the issues raised in this framework as part of the subsurface contractual risk management strategy. The WG has reviewed all the ITA propositions and they formulated it in an issues framework and during 2009 and 2010. Working group 20 contributed comments to the draft and they had two industry experts, John Reilly and Terry Mellors, to review the details of the drafts. They now have that framework ready and completed and it will be published soon. Now they are going to take the issues framework and road test it, compare it with the FIDIC document just to see whether it stands up to the clauses that are in the FIDIC contract and it is fit for purpose.

5. WG 5 — Health and Safety: Animator: Donald Lamont (United Kingdom), Vice-Animator: Martin Vogel (Switzerland), Tutor: Vitaly Umnov (Russia) Working Group 5, "Health and Safety in Works", met once during the 2010 ITA General Assembly in Vancouver. Donald Lamont from UK was Animateur. Unfortunately neither Martin Vogel from Switzerland, the vice-Animateur, nor Vitaly Umnov from Russia, the ITA Tutor was able to attend. In total, representatives from only six countries attended this year — Australia, Germany, Norway, Singapore, UK and the USA. Nevertheless this was a productive meeting.

ITA Booklet — Safety in Tunnelling

WG5 completed the update and review of the content of this booklet and a final version was submitted to the Secretariat in early autumn 2010. Financial assistance with the graphic artwork was provided by the BG Bau in Germany. No funding was required from ITA.

Guidelines for Good Occupational Health and Safety Practice in Tunnelling

WG5 was very pleased to note that this document has now been published as a dual language Croat/English text by Croatia. WG5 understands that a French language text may soon be produced by ITA.

Guidance on the safe use of temporary ventilation ducting in tunnels

This was a major work item over the past year. A final revision of this document was circulated for comment by e-mail prior to the meeting in Vancouver. Apart from the addition of some references, the text is complete and should be sent to the Secretariat within a few weeks.

Training courses — Health and Safety content

WG5 noted with approval that the excellent training course held prior to the WTC included a lecture on

occupational health and safety in tunnel construction. It also reviewed the syllabus for, and gave its support to the 2-day course on "Occupational health and safety in tunnel construction" within the portfolio of courses offered by ITA-CET.

Future work items

The number of tunnel projects which potentially require high pressure compressed air interventions was noted. No country has yet published guidance on this issue. It was therefore agreed that the WG would undertake a preliminary study of the topic, with a view to producing guidance in the future. The WG noted the British Tunnelling Society was proposing a workshop on this topic in early 2012 and would seek to be in a position to contribute to the event.

The WG recognised that shafts were an often neglected but hazardous aspect of tunnel construction and would undertake preliminary studies of the range of shaft sizes and types constructed along with their respective health and safety problems. This was with a view to liaising with South Africa and SANCOT at the 2011 GA/WTC, over possible future publications on the topic of shafts.

6. WG 6 — Maintenance and Repair: Animator: Henry A. Russell (USA), Vice-Animator: René van den Bosch (Netherlands), Tutor: Yun Bai (China).

The Working Group met on Sunday 16 May 2010. The meetings were attended by 8 representatives from 8 member nations, they were: Austria, China, Denmark, Germany, Netherlands, Norway, United Kingdom, and the United States of America.

The Working Group discussed the completion of the development of *Guidelines for Structural Fire Resistance for Metro Tunnels*. This document is an adaptation of our recent work on *Guidelines for Structural Fire Resistance for Road Tunnels*, which is on the ITA web site. This work required the inclusion of specific elements unique to passenger rail systems and the modifications time / temperature curves for heat release from fires in a passenger rail system. The Working Group has submitted the final draft to the executive council for comment. The Animateur expressed his appreciation to the following member nations for their extensive support in the development of the Structural Fire documents which they have prepared. They are France, Germany, Netherlands, Sweden, Switzerland, United Kingdom, and the United States of America.

The Working Group is pleased to announce that the conclusions and recommendations from *Guidelines for Structural Fire Protection for Road Tunnels* have been included in the latest revision to the National Fire Protection Association's, document, *NFPA 502, Standard for Road Tunnels, Bridges, and other limited Access Highways, 2008 Edition, as amended*. In addition the European Union's European railway Agency (ERA) has adopted their Guidelines and recommendations and is included in the Technical Specification for Inter-operational Safety in Railway Tunnels (TSI). This is a significant acknowledgement of the work performed by the Association and in particular of the member nations who participated in the development of the Guidelines.

The working Group has decided to continue to monitor the current events in the State-of-the art of Fire Protection in tunnels and this sub group will be led by Rene van den Bosh of Netherlands. The working group has also decided to develop a document on the control of groundwater in operational tunnels. This subgroup will be led by Henry Russell, the Animateur.

The Group wishes to invite any members of the Association who would like to participate in the development of this report to contact the Working Group members or the Animateur.

7 WG 9 — Seismic Effects: New Animator: Wenge Qiu (China), New Vice-Animator: Gary Kramer (Canada), Tutor: Jian Zhao (Switzerland) 13 members from 9 different countries were present.

Basically the agenda for the group was the re-initiation of the working group 9. The members discussed on seismic effects in tunnels and the general conclusions was that tunnels perform very well in seismic events but that is not necessarily common knowledge both in general public and in the tunnel community. So the Group established a number of objectives began a discussion on future task. The on-going activities of the WG will be the implementation of the future tasks.

Primary objective for the working group: Recognizing that properly designed and constructed tunnels and underground space perform very well during seismic events, the objective of WG 9 is to advocate their use as a safe alternative to other forms of infrastructure in highly seismic regions of the world.

Implementation Objectives

WG 9 Objectives: Primary

Responsibility: Timeframe:

Assist ITA members in the process of seismic design of tunnels by developing and making available a set of general guidelines for seismic analysis, design and detailing of tunnels. 2 to 3 years

Present guidelines in a series presentations/workshops. 2 to 3 years

Identify seismic research study needs for the tunnelling industry. 1 year

Encourage an update of state of the art design/research paper. 2 to 3 years

Update list of resources — update the bibliography on the ITA web page. 6 months

Update database of existing tunnel performance in light of recent seismic events. 1 year

Opportunity Areas I:

- Fault crossings — concepts & details for crossing/ repair
- Portals — what are the problems/design requirements

- Level of analysis — dynamic or static — 2D or 3D
- Effects in rock tunnel compared to soft ground
- Deep tunnels versus shallow tunnels
- Instrumentation of tunnels for collection seismic response data and distribution of results
- What is the magnitude of seismic events/conditions that become a problem for tunnels?
- Special detailing requirements that may be of benefit to tunnel design

Opportunity Areas II:

- Interface between tunnels and other structures (deep excavations, shafts, stations, cut-and cover)
- Modelling of tunnels — numerical, physical testing of tunnels — centrifuge, full scale
- Classification of tunnels and other underground structures with respect to building code requirements
- Areas of reported damage to tunnels — small scale and large scale
- Development of a suggested checklist for inspection of tunnels after seismic ideas & reporting forum

8. WG 11 — Immersed and Floating Tunnels: Animator: Christian Ingerslev (USA), Vice-Animator: Jonathan Baber (United Kingdom), Tutor: Yann Leblais (France)

The Working Group met on Sunday 16th May 2010. The meeting was attended by fifteen participants from nine countries, namely Canada, China, Denmark, France, Italy, The Netherlands, Norway, United Kingdom and United States. A second meeting was held the following day with thirteen of those participants.

The Working Group is continuing with production of its Owners Guide to Immersed Tunnels, the first sections of which were uploaded to the ITA server. Greater emphasis will be placed on early uploading of further sections as they are produced. The Catalogue of Service Tunnels was also uploaded, as was the Immersed Tunnel Glossary of Terms. The Working Group will continue liaising with relevant other working groups. The working group was not able to understand criticisms in the evaluation and recommendations in the Report since these items are already part of the agreed tasks. It was also noted that once constructed, the potential depth, length and operation of an immersed tunnel would be no different to that of an equivalent soil or rock tunnel. The Working Group agreed that perhaps the perception of outsiders might not adequately reflect the intentions of the Working Group and that this should be addressed by better publicizing its activities and its output as it is uploaded to the ITA server.

Attendees reported on projects in their countries and with which they were involved. PowerPoint reports were made on Limerick (Ireland), Bjørvika (Oslo, Norway), Busan-Geoje (Korea), Söderström (Stockholm, Sweden), Marieholm (Gothenburg, Sweden), HZMB and five other Chinese tunnels, Tyne (UK), The 2nd Coen and NZL (Amsterdam, The Netherlands). There was considerable discussion during these presentations.

The Working Group is working on sections for an "Owners Guide" (General Principles) as reported last year. Discussion followed to determine progress on those sections drafted during the past year. While some progress was made, the Working Group agreed to make greater efforts to speed the progress.

Sections to be prepared during the coming year and authors for these were agreed; sections will be reviewed before uploading. If further comments are received, these sections can always be updated. Of the additional sections suggested last year, fire protection, element and expansion joints, cracking and concrete construction were completed. The attendees acknowledged that other proposed sections were not completed.

The Working Group decided in future to place greater emphasis on submerged floating tunnels (SFT) as indicated in the name of the Working Group. It was also agreed that this working group is the correct forum for this. A list of topics will be prepared similar to that of the Owners Guide; these will be expanded and placed on the server. Safety, fire and flooding are topics of great importance.

In response to a request from ITA CET, a 2-day course on immersed tunnels has been prepared and the response to a call for presenters has been overwhelming.

Other tasks for the Working Group over the next few months were identified. A section will be prepared on rubber joints and extra provisions for these that are currently being demanded; research has shown that much of this may be unnecessary. Threats to tunnels was an additional section needed that would be prepared.

9. WG 12 — Sprayed Concrete Use: New Animator: Atsumu Ishida (Japan), New Vice-Animator: Odd-Bjorn Kleven (Norway), Tutor: Eivind Grov (Norway)

The meeting was attended by 19 participants coming from Brazil, Canada, Finland, France, Iran, Italy, Japan, Norway, South Africa, Sweden, Switzerland, Thailand, United Kingdom, and U.S.A.

Activities

Evaluation on fibre-reinforced sprayed concrete

The Group has agreed to recollect the valuable information of toughness testing and fibre reinforcement from many member nations. Mike McPhee and Tarcisio Celestino will be in charge of preparing questionnaire.

Nozzleman Certification

Discussion was made for future activity on this subject after Catherine Larive summarized the paper in the Southern Africa Conference on certification schemes around the world. Janne

Lehto presented a recent output of nozzleman certification from EFNARC. The group ecided

to continue this subject to endorsing the paper and the EFNARC documents in ITA web site.

Mix design and durability

After the report by Tony Boniface on curing and durability of sprayed concrete, published in the last years South African Symposium on Sprayed Concrete, the group decided to move on to the discussion on mix design and durability. Especially the difference between sprayed concrete and cast concrete are focused. The group decided to collect information regarding design and durability from member nations and industries. Tony Boniface and Odd-Bjorn Kleven will be in charge of this activity.

Water proofing

Technology of water proofing arise interest among the member of this WG. Tarcisio Celestino will compile information available to see the possibility for a future task.

Information about performance and consequences on the structural design and behaviour of the lining will be the main focus.

Information and announcement from the members

Tommy Ellison presented his recent results on Simulator for training robot operators.

Rusty Morgan announced recent publishing of his book, Shotcrete — A Compilation of Papers.

Atsumu Ishida briefly reported two international conferences on shotcrete, Shotcrete for Underground Support XI (Davos, Switzerland) and Engineering Developments in Shotcrete 2010 (Queenstown, New Zealand).

10. WG 14 — Mechanization: Animateur: Lars Babendererde (Germany), Vice-Animateur: Felix Amberg (Switzerland), Tutor: Katsuji Fukumoto (Japan)

16 Participants from 9 Countries attended the meetings in Vancouver.

Pro- and Con-List Mechanised Tunnelling

As requested by the ExCo the document has been sent out to the WG 19 "Conventional Tunnelling" for comments.

The Animateur had the chance to discuss the document with WG19. The WG had strong objections against the document but were interested to participate in the elaboration of a comparable, but commonly written document.

List of Challenging Projects

The current status of the list and the related documents has been explained. They were reviewed by the ExCo as well. Feedback is that the document would be uploaded once there is a separate email address for the submittal process. The process itself was demonstrated to the members.

Once the WG has a special email address for data response, the list is ready for upload onto the website. But they would need more project submittals from the Member Nations (MN). Only Japan submitted one project so far. The relevant pdf-forms for project submission were made available to the tenants for further distribution within the MN and will be emailed again to the WG once the address is available.

Further the WG proposed to prepare a short introduction to the "Criteria of Challenging Projects". This should include a short promotion for mechanised tunnelling and an explanation of the purpose of this document and the list itself. Nasri Verya volunteered to elaborate this introduction.

WG Animateur Questionnaire

It was agreed that the questions and limits of automation in TBM tunnelling could be a topic for later work.

Update of Download Area

It has been detected that the current documents, available for download from the WG site are at least ten years old and such outdated. It was agreed in the meeting that the documents should be updated and further documents integrated. The future documents should be a compilation of national guide lines, standards etc.

If anyone is in possession of a comparable document or for another nation, he would be invited to submit as well.

Future work in WG

Brian Fulcher proposed a document describing the general development of mechanised tunnelling. It has been discussed within the group and is viewed as a valuable part within the information purpose of this group. Due to the already listed topics for this year, it was proposed to readdress it in the next year.

11. WG 15 — Environment: Animator: Jan Rohde (Norway), New Vice-Animator: Yoshikazu Ota (Japan), Tutor: In-Mo Lee (South Korea) — Report presented by the Animator:

The Working Group met on two occasions and was attended by 6 representatives from 6 Member Nations, Sweden, Italy, Japan, Korea, United States, and Norway.

The Working Group's report on "Environmental and Sustainable Development Reasons for Going Underground" was presented in the open session the 18th May.

The future goals of the working group as they relate to environmental and social impact are to communicate the following:

- Environmental challenges by going underground
- Environmental recommendations and guidelines when going underground

It was agreed to combine the two topics in one report.

The working group also agreed upon the future programme and goals and the time schedule for the works. The working group also discussed strategies to receive more case histories on challenges and solutions and will prepare a new questionnaire requesting member nations' guidelines, statues, regulations, laws etc.

regarding environmental aspects of underground projects.

The WG will interface with all other WG on related issues.

12. WG 17 — Long tunnels at great depth: Animateur: Gérard Seingre (Switzerland), Vice-Animateur: Minoru Shimokawachi (Japan — could not attend), Tutor: Piergiorgio Grasso (Italy). The meeting was attended by 11 members from 9 different countries: Argentina, Canada, China, France, Italy, Japan, Norway, Sweden, and Switzerland.

- An extended presentation was given on the Bioceanic Central Corridor Project between Mendoza in Argentina and Santiago de Chile. On the central portion of this private new freight railway line a 52 km long tunnel is projected. The international treaty between Argentina and Chile was signed and ratified last year. The final phase of feasibility study has been started.
- Short information was given on the state of advancement of the European base tunnel projects: Lyon-Turin, Brenner and the Gotthard.
- Citybanan railway line in Stockholm (Sweden)
- Nant de Drance pumped storage power plant in Switzerland. Where one of the Loetschberg hard rock TBM is now reused to drive a 5.5 km long adit.
- The vice animateur gave a presentation on Constitution and Facilities of Long Railway- Tunnel at Great Depth in Japan.

All the presentations will be sent by e-mail to all group members.

During the final part of the meeting the future of the working was discussed. The WG report is now published. It is now downloadable on the ITA-Web site. The objective of the WG 17 has been successfully reached.

The tutor and the animateur have proposed to group members to decide to stop the WG 17 because the job has been done. The second option was to identify clear tasks on specific problem to work on. For this option the animateur asked for an active participation of group members on the writing of documents. The animateur informed group members on the analysis of Prof. A. Haack. Three proposals came from group members:

- Focus on adits: survey function, construction, final functionality, safety…
- Construction methodology selection
- Guideline: contract for long and deep tunnel (in cooperation with WG 3)

The animateur informed the working group members that he has decided to continue only for 2 years and not on the last subject.

Finally the WG members agree to let the new ITA-Board decide himself to stop or not the WG 17.

12. WG 18 — Training: Animateur: Daniele Peila (Italy), Vice-Animateur: Han Admiraal (Netherlands), Tutor: Markus Thewes (Germany). The meeting of WG 18 was attended by members from Brazil, Thailand, the Netherlands, Italy, Egypt, France and Germany. After the meeting in Budapest, last year, we agreed on a transition period with regards to the cooperation between WG18 and ITACET committee.

Following the meeting of animateurs in Vancouver and the advice given by Alfred Haack was appointed by the ExCo to look into the working of the working groups, a deep discussion on the future of the cooperation and activities was held.

The vice-animateur will write a position paper detailing the discussion. This paper will be given to Alfred Haack.

During the discussion working group members reached the conclusion that the most important tasks for which the working group was started have been completed. This includes the database of university courses, university professor network, development of courses before WTC's, and development of didactic material.

From all these activity the ITACET committee evolved and has reached a relevant number of members. For this reason WG18 members strongly recommend to the ExCo to take into account the possibility of the integration of WG 18 into the ITACET committee.

They further proposed to integrate the tasks of WG 18 into various activity groups within the ITACET committee, given that the latter has evolved from WG 18, but now provides a bigger and more diverse platform to fulfil these tasks.

Activity groups can be, but are not limited to: knowledge management, new teaching tools and methodologies, training at early level of education (pre university activity, high school, training of technicians).

With regards to the latter a questionnaire will be send to the member nations and industrial partners of ITA (like prime sponsors) to understand which are the real needs in this field. This task will be taken up either by the working group or an activity group of ITA-CET depending on the decision of the ExCo reached in terms of the proposal to integrate.

13. WG 19 — Conventional Tunnelling: Animateur: Heinz Ehrbar (Switzerland); Vice Animateur: Robert Galler (Austria), Tutor: François Vuilleumier (Switzerland)

The WG 19 had two meetings during the ITA World Tunnel Congress 2010 at Vancouver.

1st Meeting, Sunday May 24, 2010, 14:00 to 17:30

14 participants representing 12 nations attended the meeting of the working group on Sunday afternoon. The participants discussed the new project of the working group 19, the elaboration of guidelines on the special contractual aspects of conventional tunnelling. Some boundary conditions were stipulated. Also the draft of the ITA Contractual Framework for Underground Construction Contracts, a paper prepared by working group 3 was discussed at Salzburg and the

feedback was given to ITA Secretariat and to the Working Group 3.

During the Sunday afternoon's meeting of this year the participants were informed about the evaluation on our activities by the Executive Council. This evaluation suggested that there is a thematic overlapping with WG 3 and there was no real perspective for topical future work visible

The Executive Council recommends:

- Widening the definition of "Conventional Tunnelling", not only covering "NATM"
- Closer contact with the industry to find out their demands and requirements
- Thinking over merging with WG's 14 (mechanized tunnelling) and 17 (Long Tunnels at great depth)
- Focus on specific technical topics related to Conventional Tunnelling, e.g structural design, machinery, type of explosives

A discussion was held on the opinion of the Executive Council. The Working Group Members did not agree that there should be no real perspective for topical future work visible.

In a short discussion some important topics were listed which will give work for the next ten years. Future topics can be the design of the inner lining for conventional driven tunnels, the use of different excavation methods, monitoring for conventional tunnelling etc.

A merger with other groups makes no sense for the participants, due to the fact, that conventional tunnelling has its special boundary conditions. Common projects as e.g. a joint report together with working group 14 on excavation methods can make sense.

In the future the working group will try to invite more people to give presentations in the working group. This could be also an opportunity for manufacturers and contractors.

Due to the fact that Working Group 19 is working only on one topic during 3 years, the Executive Council may get the impression of low activity. They believe that it is better to produce one substantial paper every 3 to 5 years with a good quality than many papers in a short time.

After this start-up discussion they began their work on their main topic, the guidelines on special contractual aspects for conventional tunnelling. Once more the participants pointed out the big interest in such a paper related to special boundary conditions of conventional tunnelling as they are the variable round length, the variation of the cross section in a short distance, the high flexibility in the shape of the cross sections an in the use of auxiliary construction methods in the case of changed ground conditions.

The first draft of the guidelines, which was given to the participants, was considered to be too much related to the European experience with unit price contracts. The delegates from the US will prepare their viewpoint with a special focus on design-build contracts and design-bidbuild contracts.

The table of content will be changed and an additional chapter on project delivery methods will be integrated. It is the aim of Working Group 19 to have a more detailed second draft for the next meeting at Helsinki, corresponding to the working schedule fixed at Budapest.

The future work will be done in cooperation with the working group 3, "Contractual practices".

2nd Meeting, Monday 17 of May 2010, 14:00 to 15:40

11 participants represented 8 nations in the second meeting.

The only topic of the meeting was the discussion of the paper on the "Application of Tunnel Boring Machines versus Drill & Blast, Conventional Tunnelling and Submerged Tunnels", prepared by the Working Group 14.

The Animateur of Working Group 14, Lars Babendererde attended the meeting and explained the view of Working Group 14.

A very intense discussion was held. The delegates of WG 19 took the decision, that they cannot support this paper because many statements base on opinions and not on facts.

It is more target-aimed for the working group 19 to elaborate a joint paper on the different excavation methods, based on hard facts. The next Congress at Helsinki could be a good opportunity to start with this project.

14. WG 20 — Urban Problems — Underground Solutions: Animateur: Amanda Elioff (USA), Vice-Animateur: Wrout Broere (Netherlands) and Vice-Animateur: Junji Nishi (ACUUS); Tutor: Harvey Parker (USA)

Working Group 20 with the topic "Urban Problems — Underground Solutions" met twice. The meetings were well attended with 21 participants from 12 countries: Australia, Finland, France, Japan, Netherlands, Singapore, China, Italy, Iran, Hungary, UK and the USA.

As reported previously, the WG-report will be directed to planners and decision makers to provide creative and efficient ideas for the solution of urban problems and will serve as a decision aid. The focus of this product will be somewhat less on technical details but more on strategic aspects of urban planning, may they be of social, economical, ecological or aesthetical background.

The group progressed towards its objective of creating an overview of the typical challenges of urban city planning and the solutions which are offered by the underground space. The seventh draft of the working group's first product (a report on urban problems, underground solutions, and key decision factors) was reviewed among the group. The action items that originated from the Budapest meeting were reviewed and most had been followed up in the last year.

The text of the report was discussed in detail and remaining points were assigned to group members for completion or fact checking. Given the status of the report, a final draft is expected after summer 2010. An outside technical editor will be contracted with as well as a graphics designer to edit the appendix (discussed below).

Included as an appendix to the report will be a collection of 15 to 20 worldwide case history examples that will provide illustrations of notable underground solutions to urban problems.

Additional projects for these case histories were collected over the last year. A number of projects have been formatted in a uniform presentation format, and a number will be formatted in the coming period. This appendix is intended to be a "living" document, such that new projects — as they are identified — can be added and viewed on the ITA website an its links.

The meeting also included presentations on the Alaskan Way Viaduct replacement, underground projects in Shanghai, including the Hongqiao Hub and on the Japan Deep

Underground Usage Act and the project it as enabled.

Microtunnelling short course 2011

The Colorado School of Mines' 17th annual Microtunnelling short course will be held on February 8-11, 2011 in Golden, Colorado, US. The course, which has already trained more than 1,700 students, ranging from contractors and engineers to owner agency representatives, will cover the latest in emerging microtunnelling technologies.

The three-day intensive programme will be presented by a panel of international experts. It has been organised by Prof. Levent Ozdemir of the CSM and Timothy Coss of Microtunneling Inc and will include an additional one-day course on the emerging field of pilot tube microtunnelling (February 8).

Following completion of the microtunnelling short course, two continuing education credits and a certificate will be awarded.

Further information from space@mines.edu

THE DAVID SUGDEN YOUNG ENGINEERS WRITING AWARD 2011

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Win a chance to attend the 2012 ITA World Tunnel Congress in Bangkok, Thailand with accommodation

- The competition is open to all ATS Members and University Students under 35 years of age (as at 30 June, 2011)
- 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 2011
- Winner announced by 31 August, 2011
- 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 Bangkok, Thailand from 18–23 May 2012.

The winner may also be invited to be a member of the ATS Executive Committee for 12 months as the Young Engineers Representative.

For more information contact Sheryl Harrington at the ATS Secretariat: Phone 1300 653 113
Email: sharrington@engineersaustralia.org.au

CCTV course in Coffs

Following on from the success of Trenchless Live 2010, held in Coffs Harbour, Streamline Learning is offering a CCTV conduit inspection and reporting courses.

To be held at Country Comfort in Coffs Harbour, New South Wales, the four-day course will give training to operators, supervisors and managers involved in aspects of the inspection and reporting on the condition of assets.

The course has been developed in association with the Water Services Association of Australia and Underground Photographic Surveys to meet the requirements of WSA05-2008.

It has also been designed to meet the requirements of Units, NWP331B — Inspect conduit and report on condition and features (for operators) and NWP440A — Supervise conduit inspection and reporting (for supervisors and managers), from the National Water Training Package, NWP07.

Competition for young tunnel engineers

The British Tunnelling Society (BTS) is once again running The Harding Prize. Young tunnel engineers aged 33 or under (at the end of 2010), can submit an original paper on any aspect of tunnelling which they think would be of interest to those in the tunnelling industry.

Although the competition is open to young tunnel engineers in any country, the writers of papers deemed to have reached a high standard will have to attend an oral presentation at a BTS meeting in London in April.

A cheque for £500 (US$790) will go to the winner, who will also receive two tickets to the Society's annual dinner in May 2011, not to mention the publicity and kudos associated with the award. In addition, the BTS will publish the winning paper in its 'house' magazine. Runners-up will each receive a cheque for £100 (US$158), and those papers deemed to have attained an approved standard will receive a cheque for £50 (US$79).

Papers must be submitted by February 28 2011 and be addressed to The Secretary, British Tunnelling Society, One Great George St, London, SW1P 3AA, United Kingdom. Further details from bts@britishtunnelling.org.uk

International recognition for Halcrow's technical innovation in tunnelling

Malcolm Chappell, GRANIT project director for Halcrow, (L), with Prof. Albert Rodger, Aberdeen University, hold the Technical Innovation Award

At the 2010 inaugural New Civil Engineer (NCE) International Tunnelling awards, presented at a luncheon at the Grosvenor House Hotel, London on Wednesday 8 December, the Halcrow GRANIT system won the coveted Technical Innovation award.

The award citation reads, in part: This is a genuinely new application and an innovation for the future particularly as rock bolts and ground anchors become more and more important in efficient modern tunnelling. Halcrow has invested time and resources to develop a known technology so as to bring a new commercial application to the market.

Antony Oliver, Editor of NCE, commented: "These new awards are designed to celebrate and reward the input across the whole industry as you push the boundaries of innovative design, produce solutions that exceed clients' expectation, reduce the cost of delivery and make your workplaces increasingly safe for workers and the public."

GRANIT (GRound ANchor Integrity Testing) is the world's first rapid, effective, multiple capability, noninvasive anchor integrity testing system for rock bolts and cables used in mining, tunnelling and other civil engineering ground anchorage systems.

GRANIT tests by sending a series of small impulses at different frequencies through the anchorage using an electronic solenoid. Analysis of the return pulses can reveal defects such as reduced support element length, whether the support element's design or safe working load has been exceeded and potential corrosion issues.

It has the potential to provide an improved health and safety environment for individual mine and tunnel workers and can be used as part of a regular condition monitoring regime.

The system is highly productive, capable of testing up to 100 anchors per day; it is easily portable, non-destructive and offers asset owners a high degree of confidence in the reliability of the results. It has been used in places ranging from Scotland to Australia, Greece and Canada. Although GRANIT was originally invented by engineers at the Universities of Bradford and Aberdeen, Halcrow's GRANIT team has been instrumental in the development of the whole system and Halcrow now holds an exclusive world-wide licence for its deployment.

Operations are controlled from Halcrow's Melbourne office by Ben Jones, who can be contacted on +61 (0)401 446 279 or via email, jonesbe@halcrow.com

For more information on GRANIT visit www.granituk.com/

ITA-AITES World Tunnel Congress 2012 "Tunnelling and Underground Space for a global society" and ITA 38th General Assembly

BANGKOK — THAILAND, 18–23, MAY, 2012

Dear ITA-AITES EC Members and Member Nations,

On behalf of the Engineering Institute of Thailand under H.M. the King's Patronage (EIT), it is my utmost pleasure to support Thailand Underground and Tunnelling Group (TUTG) for hosting the ITA-AITES World Tunnel Congress for the first time in Bangkok, Thailand, in 2012.

In the past 20 years, like other major cities around the world, Bangkok has gone through a period of significant development in underground space utilization. Several hundredkilometers of tunnels and a large number of deep underground structures have been built in the city.

The Engineering Institute of Thailand with more than 20,000 members has been leading to facilitate the building of a better engineering society in Thailand. Under the EIT's umbrella, Thailand Underground and Tunnelling Group (TUTG) plays a pivotal role in promoting tunneling and underground construction works in Thailand. TUTG has been able to serve as an important link between local and a global tunneling and underground space society. I am confident that the WTC 2012 in Bangkok will provide another valuable opportunity and make it a significant event for the global society to exchange their experiences and knowledge.

Finally, I hope that the global tunneling and underground space society will give Thailand the opportunity it deserves to host the WTC 2012.

Prasong Tharachai
President
The Engineering Institute of Thailand

5th International Symposium on Tunnel Safety and Security in New York, 14-16th March 2012

Call for papers - First Announcement

Dear Colleague,

We are pleased to send this Call for Papers for the 5th International Symposium on Tunnel Safety and Security (ISTSS 2012), to be held at The Roosevelt Hotel in New York, USA, 14-16th March 2012. This event will bring together expertise in the field of safety and security for 3 days of presentations and exhibits. The previous symposium in Frankfurt in March 2010 was a great success with more than 240 delegates.

We hope that you are interested in taking part in ISTSS 2012 and welcome you to submit a manuscript or poster for presentation. Manuscripts and posters will be reviewed on the basis of an extended abstract of not more than two pages. Manuscript abstracts should be submitted to the Secretariat by email (istss@sp.se) by 1st June 2011, poster abstracts by the 1st September 2011.

For more information see Call for Papers or visit the Symposium website (www.istss.se) where you can find Author instruction.

If you have any questions you are also welcome to contact us.

Kind regards,

Mrs Kaisa Kaukoranta
Member of the ISTSS Organizing Committee

Contact

Kaisa Kaukoranta
Member of the ISTSS Organizing Committee

SP Technical Research Institute of Sweden, Fire Technology Department

E-mail: istss@sp.se

NO-DIG 2011

3–6 OCTOBER

down under

BRISBANE

In the lead up to No-Dig Down Under 2011 the ASTT, you are invited to three trenchless networking events being held in 2011

The future of tunnelling

Hosted and supported by Melbourne Water

4–7pm, 14 April

Melbourne Water offices, East Melbourne

HDD and geothermal

4–7pm, 12 May

Brisbane (location to be confirmed)

For more information contact Elissa Duck on 03 9248 5170.

tc28 IS Roma 2011

7th INTERNATIONAL SYMPOSIUM

GEOTECHNICAL ASPECTS
OF UNDERGROUND CONSTRUCTION
IN SOFT GROUND

16-18 May 2011, Roma, ITALY

We invite you to participate to the 7th TC28 International Symposium "Geotechnical Aspects of Underground Construction in Soft Ground" that will be held in Rome (Italy) in May 16-18, 2011.

Registration is now open in http://www.tc28-roma.org/registration/registration-form. Register now and take advantage of the early bird fee reduction!

Since Roma gets pretty busy during summer time, and due to many other events in the same period we advise that you book your hotel in advance. The TC28 IS Roma 2011 has selected different accommodation with the goal to suggest you the best stay in Roma. All hotels listed on our website are centrally located and close to the Symposium Venue.
Should you need any assistance please contact: Well Done Group (tel +39 06 99701270 – email: tc28roma@welldonegroup.it)

For further information about the Symposium, please visit the website www.tc28-roma.org.

If you have any question please contact us at info@tc28-roma.org.

We look forward to welcoming you to Rome in May 2011!

RUSSIAN EXPERIENCE AND DEVELOPMENT
OF INNOVATIVE TECHNOLOGIES FOR THE CONSTRUCTION OF
TUNNEL PROJECTS IN SOCHI

ITA CROATIA
Croatian Association for Tunnelling and Underground Structures
www.itacroatia.eu

is inviting you to the

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

USING UNDERGROUND SPACE

Preliminary Invitation
Call for Papers

ITA - AITES
International tunnelling and underground space association

Hotel-Congress Center Valamar Lacroma
April 7-9, 2011, Dubrovnik, Croatia

see you there!

:: Conference Venue

ACUUS 2012 Singapore will be held at the Marina Bay Sands, the newest landmark in Singapore. Located along the Marina Bay waterfront and in the heart of Singapore, Marina Bay Sands features three cascading hotel towers topped by an extraordinary sky park, 'floating' crystal pavilions, a lotus-inspired Museum, retail stores featuring cutting-edge labels and international luxury brands, trendy Celebrity Chef restaurants, endless entertainment at the theaters, the hottest night clubs and a Las Vegas-style casino. Business visitors will also enjoy the extensive M.I.C.E facilities featuring state-of-the-art technology.

:: Your Singapore

Singapore - the gateway to Asia - is a bustling cosmopolitan city that offers a world-class living environment, with her landscape populated by high-rise buildings and gardens. Singapore is a ubiquitous collage of cultures, where people of different ethnicity and beliefs coexist. Besides a vibrant multicultural experience, there's more you can discover about Singapore. Find out more at www.yoursingapore.com.

:: About ACUUS

ACUUS is an international non-governmental association actively promoting partnerships amongst all experts who design, analyse and decide upon the use of our cities' underground space. ACUUS promotes also the awareness of the private sector, governments at all levels and the general public on the specific issues related to the sustainable use of the urban underground. Read more about ACUUS at www.acuus.qc.ca.

CONTACT US

The Conference Secretariat
E-Quezt Concierge Pte Ltd
167 Jalan Bukit Merah #06-12 SR21 Tower 4
Singapore 150167
Tel: (65) 6271 2453
Fax: (65) 6271 2439
Email: info@acuus2012.com

7-9 November 2012
Marina Bay Sands, Singapore
www.acuus2012.com

13th WORLD CONFERENCE OF ACUUS 2012 SINGAPORE

Underground Space Development- Opportunities and Challenges

Organized by:

SRMEG
Society for Rock Mechanics Engineering Geology (Singapore)

NANYANG TECHNOLOGICAL UNIVERSITY

On Behalf of:

Associated research Centers for the Urban Underground Space
Association des Centres de recherche sur l'Utilisation Urbaine du Sous-sol

Supported By:

MND SINGAPORE
Ministry of National Development

5th International Symposium on Tunnel Safety and Security in New York, 14-16th March 2012

Call for papers - Second Announcement

Dear Colleague,

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If you have any questions you are also welcome to contact us.

Kind regards,

Mrs Kaisa Kaukoranta
ISTSS Organizing Committee

SP Technical Research Institute of Sweden - Phone +46 10 516 50 00 - www.sp.se

7 – 9 November 2012
Marina Bay Sands, Singapore
www.acuus2012.com

13th WORLD CONFERENCE OF ACUUS 2012 SINGAPORE

13th WORLD CONFERENCE OF ACUUS 2012 SINGAPORE

The 13th World Conference of the Associated research Centers for the Urban Underground Space (**ACUUS 2012 Singapore**) will be held in Singapore during 7-9 November 2012. This conference will be organised by the Society for Rock Mechanics & Engineering Geology (Singapore) in collaboration with the Tunnelling & Underground Construction Society Singapore, Nanyang Technological University, and Tongji University of China, and is supported by the Signapore Ministry of National Development and the Singapore Convention and Exhibition Board.

The main theme for **ACUUS 2012 Singapore is "Underground Space Development – Opportunities and Challenges."** This theme was chosen to emphasize the unprecedented opportunities for improving urban infrastructure and urban livability while recognizing the special challenges faced in creating underground spaces - technical, economic, and design challenges in order to address human psychology of underground habitation.

ACUUS 2012 Singapore will provide an excellent forum for engaging discussions and exchanges among planners, engineers, researchers, and policy makers. In addition to the technical programme, there will be technical visits, exhibitions and social programmes for conference attendees and accompanying persons. There will also be opportunities to sign up for pre-conference workshops, short courses and special sessions.

CALL FOR PAPER

Interested authors are invited to submit an abstract of not more than 300 words. Visit our website to find out more about the theme and topics.

Abstracts submission via www.acuus2012.com begins in March 2011.

SPONSORSHIP & EXHIBITION

Attractive packages for exhibition and sponsorship will be available for organizations that wish to showcase and market their services and products in the rapidly growing markets in Singapore and the rest of Asia. Contact the Conference Secretariat to find out more.

CONTACT US

For developments of **ACUUS 2012 Singapore**, please visit our website at www.acuus2012.com or contact the Conference Secretariat at email: info@acuus2012.com or tel: 65 6271 2453.

We look forward to your participation at **ACUUS 2012 Singapore**!

FIRST ANNOUNCEMENT
AND CALL FOR PAPER

Sixth International Symposium on
SPRAYED CONCRETE
- Modern Use of Wet Mix Sprayed Concrete for Underground Support

Tromsø, Norway, 12.- 15. September 2011

www.sprayedconcrete.no

ITA-AITES

NB norsk betongforening

Tekna

ATS Tunnel Database

NEW SOUTH WALES

Project:	Sydney CBD Metro		
Client: SMA	**Designer** PB/Arup	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Sydney CBD West Metro will initially run from Central to Rozelle and eventually to the north west	**Current status:**	Cancelled

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:	Burrow Road Tunnel		
Client: Enery Australia	**Designer** Demlakian Consulting Engineers	**Contractor:** Abergeldie Complex Infrastructure	**Supervising Engineer:**
Scope of work:	87m long and 2800mm diameter tunnel is approximately 5m below Burrows Road in Alexandria, Sydney	**Current status:**	Complete

Project:	Mardi-Mangrove pipeline		
Client: Gosford City and Wyong Shire Councils	**Designer**	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	Two pipelines, including 1.9 kilometre section from Wyong River to Mardi Dam, which will be microtunnelled	**Current status:**	Construction commenced to be completed June 2011

Project:	Central Coast Rail Upgrade		
Client: RIC	**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.

Project:	M5 East tunnel widening		
Client: RTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Provision of additional four new lanes in a tunnel(s) next to the existing the M5 East tunnel	**Current status:**	Proposed

Project:	F3 to M2 Road Tunnel		
Client: RTA and Federal DOTARS	**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:**	Preferred corridor selected. Preparing the Terms of Reference for development of a concept proposal Construction timetable for the project is yet to be established

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:	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

Project:	Bells Line of Road		
Client: RTA	**Designer** Maunsell.	**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:	Murrurundi Freight Rail Tunnel		
Client: ARTC	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Freight rail tunnel through the Liverpool Ranges at Murrurundi	**Current status:**	Shelved

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 though Cabramatta Railway Station.	**Current status:**	Tenders currently being reviewed

Project:	City East Cable Tunnel		
Client: EnergyAustralia	**Designer** AECOM	**Contractor:**	**Managing Contractor**
Scope of work:	3.2 km TBM tunnel from Surry Hills to Sydney CBD including connections to existing and proposed substations	**Current status:**	Detailed Design

Project:	Wynyard Pedestrian Tunnel		
Client: Barangaroo Delivery Authority	**Designer**	**Contractor:**	**Managing Contractor**
Scope of work:	1.4 million, 200-metre long nine metre wide walkway linking Barangaroo with Wynyard station	**Current status:**	Financing approved

Project:	Tintenbar to Eewingsdale upgrade		
Client: RTA	**Designer**	**Contractor:**	**Managing Contractor**
Scope of work:	Twin 11m diameter tubes beneath St Helena Hill over a distance of 300m as part of 17km upgrade to Pacific Highway	**Current status:**	Financing approved

QUEENSLAND

Project:	Airport Link & Northern Busway		
Client: Queensland Government	**Designer** PB Arup	**Contractor:** Thiess/John Holland JV	**Supervising Engineer:**
Scope of work:	$4.3B PPP project. Construction of road tunnels and a busway including Australia's longest road tunnel at 6.7km long	**Current Status:**	Breakthrough of roadheaders between Bowen Hills and Truro Street in June 2010. Breakthrough of busway tunnel at Lutwyche in October 2010. Both TBMs. Rocksy and Sandy (Westbound) are well underway and will tunnel until end July 2010

Project:	Northern Link		
Client: Brisbane City Council	**Designer**	**Contractor:** Transcity - Acciona, Ghella BMD Constructions	**Supervising Engineer:**
Scope of work:	2 x 4km road tunnels from Towong to Milton	**Current Status:**	Contractor appointed. Construction expected to start in March 2011 and to be complete by 2014

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 Main Roads	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	42km road costing $1B+ will include 735 m twin tube tunnel at top of Great Dividing Range	**Current status:**	Pilot tunnel completed. Project on hold awaiting funding

Project:	Cross River Rail		
Client: DoT&MR	**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	**Current status:**	Feasibility study is continuing

Project:	Inner Orbital Tunnel		
Client: Queensland Main Roads	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	8km road tunnel between Toowong and EvertonPark	**Current status:**	Planning complete and included in the Western Brisbane Transport Strategy

Project:	Stafford Road Tunnel		
Client: Queensland Main Roads	**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. Early design options to be developed before Christmas 2010

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 Study including preferred route identification and preliminary costing, report submitted

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:	Two 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. Larger tunnel complete and TBM retrieved from below seabed. Smaller tunnel due for completion mid-September 2010 with retrieval from below seabed.	**Current status:**	Desalination plant is expected to be completed and operating by end 2011

Project:	Northern suburbs sewer		
Client: Water Corporation	**Designer** N/A	**Contractor:** DM Civil	**Supervising Engineer:** N/A
Scope of work:	4.4 km section of sewer pipe through the suburbs of Woodvale, Kingsley, Madeley and Wanneroo	**Current status:**	Sewer construction is expected to be completed by 2011

Project:	The Perth City Link Project		
Client: Public Transport Authority	**Designer** N/A	**Contractor:** N/A	**Supervising Engineer:** N/A
Scope of work:	Lowering twin Fremantle lines underground in cut and cover tunnel above existing Joondalup line bored tunnels west of Perth Central Station. Lowering of Wellington Street Bus Station underground with bus access ramp to west	**Current status:**	Perth City Link Rail Project currently in Alliance TOC evaluation mode, with award expected in March 2011. Rail lowering project due for completion in 2014. Bus station lowering project due to follow, with completion by 2016

Project:	The Perth City Link Project		
Client: Gorgon Joint Venture	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	The Gorgon field is centered about 130 kilometres off the north-west coast of Western Australia, The subsea gas-gathering system will be located on the ocean floor over the Gorgon gas fields. Micro tunnelling is expected to be a key part of bringing the gas ashore	**Current status:**	In Planning

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:**	Stage 1 — expected to start construction in 2012 and be completed by 2018

Project:	East-West Tunnel		
Client: VicRoads	**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 Rd	**Current status:**	Study planned

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:**	Construction is not expected to start until at least 2013, and depends on Federal Government support for funding

Project:	Northern Sewer Project		
Client: Melbourne Water	**Designer** SKM/Jacobs	**Contractor:** JHG	**Supervising Engineer:**
Scope of work:	Stage 1 - 8km of 1.6m and 2.5m diameter sewer tunnels. Stage 2 – 4.5km and 1.8km diameter sewer tunnels	**Current status:**	Final tunnel has been completed. Tunnel lining operations and connections to the existing sewer network expected to be completed by mid-2012

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:**	In planning. Two-year government consultation process

Project:	Wonthaggi Desaliantion Plant		
Client: Department of Sustainable Energy	**Designer** GHD	**Contractor:** Thiess Degremont	**Supervising Engineer:** TBA
Scope of work:	Desalination plant will include intake and outake tunnels offshore up to 2.5km long	**Current status:**	Construction commenced

Project:	Melbourne Main Sewer Replacement		
Client: Melbourne Water	**Designer**	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	$220 million 2.3km 1.8m diameter new sewer includes six shafts 10–15m deep and 142m crossing of Yarra River	**Current status:**	First tunnel breakthrough has been achieved, Project completion in 2012

Project:	Frankston Drainage Improvement Project		
Client: Melbourne Water	**Designer**	**Contractor:** Winslow Infrastructure	**Supervising Engineer:**
Scope of work:	1.5 kilometre 3 m OD tunnel with 2.5 m dia concrete stormwater pipeline from Monash University to Kananook Creek	**Current status:**	Complete

Project:	Regional Rail Link		
Client: DoT	**Designer** KBR/Arup	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential rail tunnels under Footscray as part of the broader Regional Rail Link project from Werribee South to Southern Cross Station via Tarneit	**Current status:**	Business case study in progress

Project:	North East Link		
Client: LMA	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential road tunnel from Greensborough to Bullen linking the Western Ring Road to the Easten freeway	**Current status:**	Not before 2018

SOUTH AUSTRALIA

Project:	Adelaide Desalination Plant		
Client: SA Water	**Designer**	**Contractor:** Winslow Infrastructure	**Supervising Engineer:**
Scope of work:	11.5 km pipeline from Port Stanvac to the Happy Valley water treatment storage facility including 6 tunnel bores ranging from 30 to 160m	**Current status:**	Tunnel works complete

NORTHERN TERRITORY

Project:	Darwin Water Main		
Client: Darwin City Council and the Department of Planning and Infrastructure	**Designer**	**Contractor:** Winslow Infrastructure	**Supervising Engineer:**
Scope of work:	Construction of several major water mains will take place in two stages. Stage 1 includes installing 1.2 km of 450mm steel pipe. Stage 2 includes the installation of 9 km of 450 mm steel water in Darwin's CBD	**Current status:**	Complete

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:**	Proposed

NEW ZEALAND

Project:	Homer Tunnel Upgrade		
Client:	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	2 Lane tunnel	**Current status:**	In planning

Project:	Victorai Park Tunnel		
Client: Transit NZ	**Designer** V Formation (Fletcher Construction, Beca Engineering, Higgins Contractors and Parsons and Brinckerhoff)	**Contractor:**	**Supervising Engineer:**
Scope of work:	440m long 2 Lane tunnel	**Current status:**	Excavation breakthrough complete at Beaumont St.More than half of the tunnel's 360 30-tonne roof beams are now in place and sections of tunnel roof have already been completely closed in along with many of the tunnel's 52 floor slabs

Project:	Milford Dart Tunnel		
Client: Milford Dart Co.	**Designer** URS	**Contractor:**	**Supervising Engineer:**
Scope of work:	10.2 kms 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:	3.5km tunnel beneath Albert St and including underground stations near Wellesley St and Karangahape Rd.	**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 Mt 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