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SUSTAINABLE, GROUND CONSOLIDATING, WATERPROOFING
RELIABLE, FLEXIBLE, DESIGN OPTIMIZING, LOW REBOUND
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SUSTAINABLE, GROUND CONSOLIDATING, LOW REBOUND

East Side Access wraps up excavation, designers discuss use of explosives



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IT'S LATER THAN YOU THINK

AS THE tunnelling community plans to descend upon London for the British Tunnelling Society conference next month, Mayor Boris Johnson has set out a GBP 1.3 trillion (USD 2.2 trillion) development plan that lays down a treasure trove of underground opportunities for the city. The plan outlines the infrastructure developments needed to keep pace with London's growth.

No doubt the talking heads at the September conference will presenting some of the mega projects in Johnson's weaponry.

Not least amongst the plans are three projects already heavily debated: the giant Thames Tunnel, part of the London sewerage upgrades; High Speed Two, linking Birmingham and the north of England with fast rail connections to London and Europe; and Crossrail Two, the next mega metro project planned for the city.

London is a city in growth. The population peaked in 1939 at 8.6 million and is expected to surpass that this year.

In Johnson's infrastructure plan, the population of the city is forecast to reach 9.5 million on the low estimate and 13.4 million in the high.

This growth will take its toll on London's infrastructure network, and the situation with public transport will be exacerbated by growth in commuter journeys into the city. The forecasts in the mayor's strategy document show an 80 percent increase in rail trips by 2050.

To cope with the growth the mayor has proposed extensive upgrades to the network. An appendix of projects giving just the salient points run for some 26 pages, and includes 76 projects.

Among the most expensive of those given are the GBP 12.6bn (USD 21.22) upgrade of the Picadilly, the Central and the Bakerloo lines, the GBP 2.6bn (USD 4.37bn) Bakerloo Line extension, the GBP 10bn (USD 16.84bn) underground stations

Jon
Young
Editor




upgrade scheme, the GBP 20bn (USD 33.63bn) Crossrail Two line, the GBP 16bn (USD 26.94bn) High Speed Two line and the GBP 20bn (USD 33.63bn) Crossrail Three line (to connect Waterloo and Euston).

As Bill Grose, formerly a director of infrastructure at Arup, among other commentators, has argued, the phasing of these projects will have a massive influence on cost.

If the projects can be scheduled to commence one after the other, there will be less competition between jobs among the contractors and suppliers.

With the impetus the mayor has placed behind this plan to 2050, now is the time to get lobbying.

The campaign for Crossrail (at least in the project's current form) took some 15 years to get the bill passed by government. And it will have taken at least 10 years from passing the bill to the first trains running.

Part of the discussion in London at the BTS conference will likely cover what can be done by the industry experts to get these potential projects out of strategy documents, and in to the ground 

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



Cover

Workers prepare rebar in this photo from May on the East Side Access project in New York. Courtesy of MTA.



Next issue

Tunnels looks at progress on Rio de Janeiro's Metro Line Four. This issue will also contain 2014 BTS Harding Prize award winning paper, and a look into the rising interest in water mist spray systems for fighting fires in tunnels. Crossrail C310 will also be featured.

This month...

5 YEARS AGO

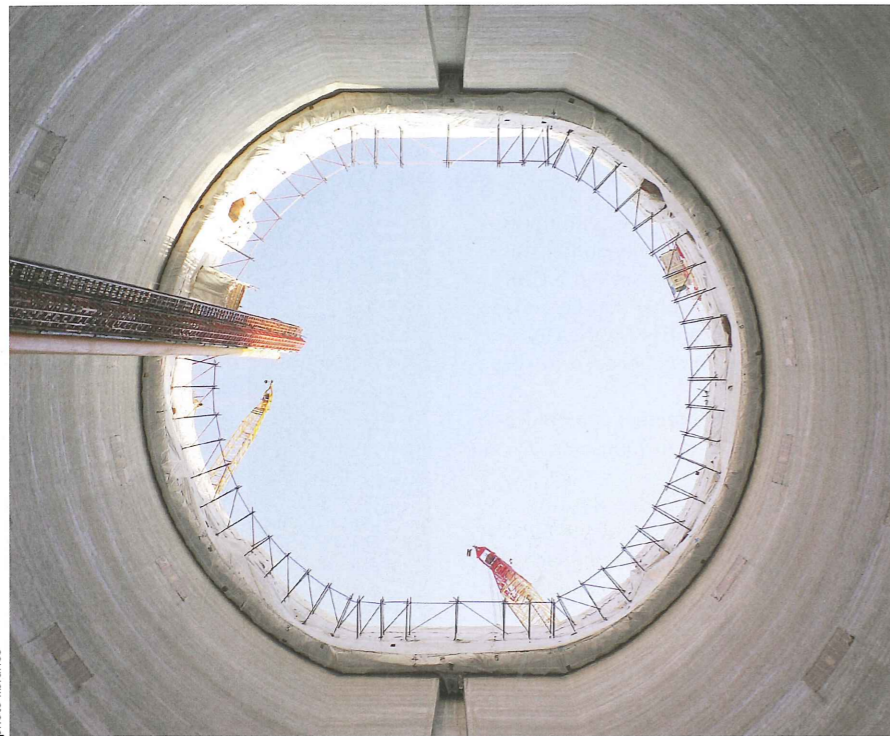
The Gautrain project is nearing completion. Some 14km out of a total 15km of South Africa's rail tunnel project have been completed and breakthrough on the final section is expected before the end of the month. The contractor, a Bouygues-led JV has carried out excavation using a 6.68m Herrenknecht TBM, and drill and blast. The underground route of Gautrain extends from Johannesburg's Park Station in the south, to Parktown Ridge, and on to Rosebank, Sandton to where it surfaces at the Marlboro portal. The scheme was developed by Bombela Civils, and the tunnel was designed by Atkins. Government estimates suggest the finished project will see a minimum of six trains running per hour, carrying 300,000 passengers per day.

Tunnels and Tunnelling, August 2009, p.7

10 YEARS AGO

Crossrail is to go ahead. Last month, UK transport secretary Alistair Darling launched his Future of Transport White Paper, saying "We intend to introduce a hybrid bill at the earliest opportunity to take the powers necessary for Crossrail to be built". Darling added that the cost of USD 18.4bn makes it a huge challenge to both deliver and fund, and that cost control would be key. Norman Haste, CEO of Cross London Rail Links said that 75 per cent of the public who responded during consultation phases agreed with the concept of the project.

Tunnels and Tunnelling, August 2004, p.4



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GRANDS PROJETS



Left: All excavation on New York's East Side Access project has completed
PHOTO: MTA

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BTS

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Andy Thompson, Hatch Mott
February's joint BTS/Minsouth meeting was treated to this talk on ESA's use of explosives

Contributors

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Bernadette is a regular contributor to *Tunnels* and editor of *Underground Utilities*. In this issue she reports on the Doha Metro project, and gives a view of work prospects in the area.

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Raoul is applications project manager at lighting provider, Schreder. Among his responsibilities, he is responsible for energy efficient developments.

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Jérôme is a project manager at R-Tech, part of the Schreder Group that is responsible for research and development. With Raoul, he presents some of the improvements available in tunnel lighting thinking.

ANDY THOMPSON
Andy is vice president of Hatch Mott MacDonald and is the program manager for construction on the East Side Access project in New York, reporting to the project executive.

AECOM IN STUNNING URS ACQUISITION

USA Aecom and URS Corporation announced on July 13 the execution of a definitive agreement under which Aecom will acquire all outstanding shares of URS for a combination of cash and stock valued at approximately USD 4bn or USD 56.31 per URS share, based on the AECOM closing share price as of July 11, 2014. Including the assumption of URS debt, the total enterprise value of the transaction is approximately USD 6bn.

The combined company will be a leading, fully integrated infrastructure and federal services provider with more than 95,000 employees in 150 countries. It would have calendar year 2013 pro forma revenues of more than USD 19bn.

"This combination creates an industry leader with the ability to deliver more capabilities from a broad global platform to reach more clients in more industry end markets," said Michael S. Burke, AECOM president and chief executive officer.

Martin M. Koffel, chairman and chief executive officer of URS, stated, "This

is a compelling strategic combination that we believe will benefit our clients, stockholders and employees. URS stockholders will receive significant, immediate value from the transaction and will be able to participate in the future prospects of the combined company, which we expect will be better positioned to compete for major, complex projects across a diverse range of end markets and geographic regions."

Aecom will become one of the largest companies by revenue in the engineering and construction industry. The combined firm will be headquartered in Los Angeles and will be the largest publicly traded company in that city. Aecom also expects to maintain a key operational presence in San Francisco, where URS is headquartered.

Michael S. Burke will be the combined company's chief executive officer, and the companies have designed a new operating management structure that will include proven senior leaders from both URS

and AECOM. John M. Dionisio, Aecom executive chairman, will be chairman of the board and, at closing, AECOM will elect two URS board members to the Aecom Board of Directors.

The terms of the definitive agreement have been unanimously approved by the Boards of Directors of both companies. The transaction is subject to customary closing conditions, including regulatory approvals, approval by URS stockholders of the merger agreement, and the approval by AECOM stockholders of the issuance of shares in the transaction. The transaction is expected to close in October 2014.

"Building on AECOM's experience of adding new skill sets and delivering them across our established global platform, we anticipate a smooth and seamless integration," said Burke. "We are developing integration plans that will enable us to bring together the best of both organizations. The process will be led by executives of both companies."

Strabag to build Mid Halton tunnel

Canada Strabag announced July 17 it has secured a new contract in Canada to build the Mid-Halton Outfall Tunnel for CAD 79 million (USD 73.5M). The project centres on the excavation of two 60m deep shafts and a 6.3km rock-bored tunnel that is designed to carry treated effluent water from the water treatment plant in Oakville into Lake Ontario.

Since the year 2005, Strabag has been present in Canada in the fields of civil and ground engineering as well as tunnelling. "We had entered the market with our first, successful project in Canada - the planning and the construction of a water diversion tunnel at the Niagara Falls.

In this project the world's largest hard-rock tunnel boring machine was deployed," recalls Thomas Birtel, CEO of Strabag SE. Ever since, most of the jobs Strabag has been engaging in Canada have involved the

construction of tunnels and shafts. The latest contract has solidified the company's presence there.

The Mid-Halton Outfall Tunnel will consist of two reaches: The onshore reach will span 4.1km, while another, 2.2km reach will be built offshore, ending in a diffuser array beneath Lake Ontario.

A TBM with an excavation diameter of 3.6m will mainly drill through layers of shale and limestone.

Construction was set to begin in mid-July 2014 and was expected to be completed within a 39 month period.

Isarco River portion of Brenner awarded

Austria Salini Impregilo, together with Strabag, Consorzio Cooperative Costruzioni CCC and Collini Lavori, has received a provisional award for the contract to build an underpass beneath the Isarco River - the southern segment of the Brenner Base Tunnel

rail project, the company announced July 7.

The overall value of the project is estimated at EUR 300M (USD 405.81M), of which Salini Impregilo has a 41 per cent share.

Salini Impregilo and Strabag won the "Isarco River Underpass" contract just a few months after winning the principal "Tulfes-Pfons" contract in Austria of EUR 380M (USD 514M). Tulfes-Pfons is the main segment of the Brenner Base Tunnel, part of the Trans-European Networks (TEN).

The contract for the "Isarco River underpass" is the final segment of the 64km Brenner Base Tunnel project, the longest underground railway connection in the world and the primary element of a new railway line that will connect Munich and Verona, Italy.

Passenger trains travelling this railway corridor will be limited to maximum speeds of 250km per hour. Travel time on the current line is roughly 80 minutes, which will be reduced to

approximately 25 minutes once the new line is completed.

The "Isarco Underpass" is the southern segment of the Brenner Base Tunnel, located in Prà di Sopra in Italy's Bolzano province.

Planned construction for the project will include civil works for the two main tunnels for a total length of roughly 4.3km, as well as two interconnecting tunnels for a total length of 2.3km that connect with the existing railway line.

Construction will be extremely complex from a technical point of view: both the main tunnels and the interconnecting tunnels will pass beneath the Isarco River, A22 motorway, SS12 state motorway and the Verona-Brenner railway line with minimal leeway. The project will conclude with environmental recovery efforts in the areas affected by construction.

Work is scheduled to begin in the second half of this year, and continue for eight years.



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Tunnel tactics continue in Syria conflict

Syria A tunnelled 'bomb' has been used to blow up a police building in Aleppo, Syria. According to the UK-based Syrian Observatory for Human Rights 13 loyalists to President Bashar al-Assad were killed in the attack. The Islamic Front, the rebel group responsible for the attack, put the death toll at 57.

News network Al Jazeera reported the explosives were placed in three tunnels running under historically significant parts of Aleppo. Fighting has been intense for the last week in this area, which is divided between rebel and government control.

"The attack is meant to break the government's first defence line to Aleppo Castle [in the centre of the city] and storm the area," an Islamic Front spokesman revealed.

Earlier this year, the Carlton Hotel in Aleppo was destroyed by an underground explosives cache. The hotel was being used as a military base, and 14 soldiers were killed. The rebel miners had worked their way across the

frontlines of the conflict. European commentators likened it to the tactics of the First World War.

Tunnels are being dug with rudimentary tools, such as pick axes, because mechanised methods would be detected.

Tunnel highway project in quandary

Nepal The Nepali government on 12 July asked Nepal Purwadhar Bikas Company Limited (NPBCL), the developer of Kathmandu-Hetauda Tunnel Highway, to provide the details of latter's funding plan within two weeks.

The instruction has come at a time when NPBCL has been facing criticism of being unable to collect resources for the project and show reliable sources for funding. Based on concession agreement clause, NPBCL had submitted financial closure to Ministry of Physical Infrastructure and Transport (MoPIT) two months ago.

A technical committee under MoPIT has been going through the documents to ensure that the firm

has resources required to undertake the project. MoPIT said that the developer planned to pool in resources through 20 per cent local funding and 80 per cent foreign investment. The 58km tunnel highway project is estimated to cost NPR 35bn (USD 358M).

"After going through the company's financial closure, the committee sought some clarifications regarding the funding flow last week," said Tulasi Prasad Sitaula, secretary at MoPIT, adding the NPBCL has been asked to come up with its explanations within two weeks.

MoPIT will make its decision after the committee completes its study. Sitaula said that if NPBCL fails to make the funding plans more transparent, they will have no other option but to terminate the contract.

As per the concession agreement reached between MoPIT and NPBCL in May last year, the government can scrap the permission issued to build the tunnel highway in case it is unsatisfied on any grounds after giving chance to the developer to provide clarification. MoPIT

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officials said that even as the project was so big, the NPBCL documents that were submitted two months ago show that it had managed to collect only around NPR 300M (USD 3M).

The tunnel highway project, aimed at linking the capital with Hetauda within one hour drive, is the first of its kind being implemented after enactment of the BOOT Act eight years ago.

To build the tunnel highway, NPBCL is planning to sign loan agreement for NPR 28bn (USD 290M) with a Canadian infrastructure development company and also issue initial public offering (IPO) of NPR 5bn (USD 52M).

ISRAEL FEARS HAMAS TUNNEL THREAT

Israel/Gaza The Israel Defense Forces (IDF) will not cease military operations in Gaza until all tunnels constructed by Hamas have been destroyed. Prime Minister Benjamin Netanyahu made the vow before a cabinet meeting on 31 July adding that it would hold true with or without a ceasefire.

Similar to recently discovered excavations, one tunnel found last year was, after investigations, found to be 1.5 miles (2.4km) long and up to 20m deep, using 800t of concrete and estimated to cost USD 10M.

It was equipped with electricity, and had chambers with provisions to last occupants extended periods of time. Pedal-operated tools were used for excavation.

From early use of tunnels for smuggling restricted materials (weapons, building supplies, and even KFC) past

IDF checkpoints, Hamas moved into more daring territory for its underground activities. Bunker complexes were created to protect commanders, and clandestine routes into Israel to allow the deployment of strike teams have been dug.

It is the latter use which allowed the famous kidnap of an Israeli soldier in 2006, and earlier this month facilitated a mission to infiltrate and attack a kibbutz in the country's south.

Another recent raid targeted a patrol Jeep and fighters were equipped with tranquilisers.

Investigating one such location on 30 July, IDF soldiers were killed entering a tunnel that had been preemptively booby trapped by Hamas forces. One explosive device was concealed within the tunnel, while a second was in the house above the portal, collapsing the structure.

Since the start of the current Operation

Protective Edge, the IDF claims to have uncovered 23 tunnels with 66 access points. With detection the most important part of the tunnel war for Israel, the Times of Israel newspaper has reported that the IDF considered, but didn't follow up with procuring the work of Paul Bauman, who holds the position of technical director of geophysics for WorleyParsons' Canadian business.

Bauman is an expert in below-surface exploration with electrical resistivity tomography (ERT). While it is not foolproof, it is thought a combination of several techniques including radar, tomography and seismic measuring could go some way to mapping the area's covert use of underground space.

Fighting in the region has escalated in recent weeks, with over 1,700 Palestinians, and over 50 Israelis having lost their lives at the time of writing.

ROAD REPAIRS TO PATCH KUALA LUMPUR SINKHOLE TO LAST 2 WEEKS

Malaysia The area where the sinkholes appeared at the intersection of Jalan Imbi- Jalan Pudu in Kuala Lumpur will be closed for two weeks to enable repairs to be carried out, "Bernama" (National News Agency of Malaysia) reported 2 July.

Kuala Lumpur City Hall (DBKL) project implementation and maintenance deputy director-general Datuk Mohd Najib Mohd told reporters at the scene of the incident that the repair work is being carried out.

In the 9.30am incident on 2 July, a section of the 35m tunnel under construction to build a four-lane underpass collapsed, causing a 5m deep sinkhole.

Azizan Ismail, Kuala Lumpur Fire and Rescue Department assistant director (operations), said there were two soil

movements detected in the area at 9.30am and 12.20pm.

"We fear there may be more cave-ins along the tunnel," he said.

Azizan said a Syarikat Bekalan Air Selangor (Syabas) pipe broke during the cave-in, and Syabas has been requested to seal the pipe to avoid worsening the situation.

"As a temporary safety measure, the contractor is now pumping water out from the site before piling work can be carried out to strengthen the area," he said. Azizan added that the Department is still waiting for investigation by Syarikat Prasarana Negara, the KL Monorail operator, to ensure the monorail pillars at the location were not affected.

Meanwhile, Mass Rapid Transit Corp.

Sdn Bhd (MRT Corp.) has denied that the road collapse at the Jalan Pudu-Jalan Imbi-Jalan Hang Tuan intersection on 2 July was connected with the MRT project.

"MRT Corp wishes to state unequivocally the alignment of the MRT Sungai Buloh-Kajang Line does not pass that location," they said in a statement. MRT Corp. advised motorists to heed all traffic signage implemented by the Dewan Bandaraya Kuala Lumpur (DBKL) and the police.

Kuala Lumpur Fire and Rescue Department said that the tunnel, which is part of Pudu underpass project by Kuala Lumpur City Hall (DBKL), sunk twice. It said two excavators were in the tunnel when the incident happened, but no casualties were reported.

Railway project gathers steam

Qatar Significant progress has been made on the Lusail Light Rail Transit (LRT) project as over 7km of tunnel construction and main civil works for seven underground stations have been achieved, according to senior Qatar Rail officials.

Some 100 per cent of the excavation works, 98 per cent of the structure of underground stations and 100 per cent of a bridge that goes over the Al Khor highway have also been completed, a spokesman added.

Qatar's Minister of Transport Jassim Seif Ahmed al-Sulaiti was briefed on these and other aspects of the project during his recent visit to the work sites of the LRT project in Lusail.

The minister was accompanied by senior Qatar Rail officials, including managing director Abdulla Abdulaziz al-Subaie, CEO Saad al-Muhannadi and deputy CEO Hamad al-Bishri.

Al-Subaie briefed the minister on the progress of the project, explaining that

the LRT project consists of four operating lines, 33km of network and 37 stations (including 10 underground).

The LRT will also be connected to the Doha Metro Red Line North via two main stations, Lusail Marina/The Pearl and Lusail's main station. The connectivity will facilitate easy transportation from and into Lusail City.

The LRT is one of the most important ventures benefiting real estate development projects in Lusail City and the project is progressing as scheduled.

"At Qatar Rail, we consider that the LRT is pivotal for the transport infrastructure in the country and it reflects the promising vision of Qatar," said al-Subaie.

The Lusail LRT System will provide an efficient and comfortable commuting system for the inhabitants of Lusail City when the mixed community development is completed.

Preferred bidder for Northern Line extension named

Great Britain London Underground (LU) has

announced that a Ferrovia/Laing O'Rourke joint venture is the preferred bidder for the Northern Line Extension contract. LU invited tenders from four bidders (for the design and build contract, which involves construction of 3.3km of 5.2m i.d. twin tunnel and two large-scale stations, one at Battersea and one at Nine-Elms. Following the tender evaluation process, the two highest scoring bidders - Ferrovia/Laing O'Rourke and Balfour Beatty/BAM - were invited to participate in the next phase of the procurement process.

Those to miss out included Bechtel/Strabag JV; and a Costain/Drageados/Sir Robert McAlpine JV.

A Transport for London spokesman said: "Following negotiations with the two remaining bidders for the Northern Line Extension design and build contract, London Underground has selected Ferrovia Agroman Laing O'Rourke Joint Ventures as the preferred bidder. Contract award is planned for late August 2014.

The proposed start of construction for the Northern line extension is spring 2015.

Four killed in Guizhou rail tunnel cave-in

China Four people were killed and another four badly injured when a high-speed railway tunnel, being constructed in southwest China's Guizhou Province, collapsed on 1 July, Xinhua News Agency reported, quoting sources in Guiyang.

Rescue efforts ended on 2 July for the workers trapped by the Dadu Mountain tunnel cave-in, which occurred at 11 a.m. on 1 July, said the Guizhou Provincial Work Safety Administration.

Rescuers pulled out the bodies of four workers and brought four injured persons to the local hospital, where they were declared stable.

The cause of the accident is being investigated.

The tunnel belongs to the high-speed railway line linking east China's business hub of Shanghai and Kunming, capital of southwest China's Yunnan Province, a major component of the Chinese government's efforts to construct more high-speed railway lines to speed up the flow of goods within the country.

SMART DOUBTS ANSWERED

Malaysia Due to a series of recent, frequent flash floods, Klang Valley residents have begun to dread the sound of thunder.

Many cannot help but doubt the effect of all the flood mitigation projects in place, especially the Stormwater Management and Road Tunnel (SMART) that has not ended flood woes in Kuala Lumpur.

Malaysia's Department of Irrigation & Drainage (DID) director-general Datuk Ahmad Husaini Sulaiman, however, explained that the recent floods were not related to the operations of the Smart Tunnel, but were localised and possibly caused by clogged drains.

According to Ahmad Husaini, there are two types of floods in Kuala Lumpur and in most urban areas – river flooding and flash floods.

River flooding occurs when a river is unable to support the extra discharge during a downpour, thus overflowing or its water level rises so high that it is impossible for water from the drains to flow in. On the other hand, flash floods are localised and are related to an area's internal drainage.

"Before the Smart Tunnel was built, most floods in Kuala Lumpur were related to Sungai Klang and the flood waters took a long time to recede," he said. "The Smart Tunnel was built to address the issue of river flooding by diverting extra water from Sungai Klang."

Besides the possibility of clogged drains, Husaini said unusually intense rainfall was the cause of the recent series of flash floods.

"The trend of rainfall is higher than normal,

maybe because of global warming."

Because of this, he could not identify the flooding hotspots in the Klang Valley.

"It is difficult to tell where flash floods tend to occur, as they are all over the place because the case now depends on where the rain falls.

"This pattern of unusually intense rainfall has been occurring over the past 10 years. DID and local authorities are looking at the need to upgrade internal drainage in specific areas," he said, adding that local authorities have also been diligently making sure that drains were not clogged.

Meanwhile, many Klang Valley residents have blamed the MRT construction works as a possible contributor to the frequent flash floods of late but Husaini begged to differ.

"Floods were happening even before the MRT construction began and I do not think it is fair to point fingers at that," he said.

On future flood mitigation plans, Husaini said it would be an ongoing process.

"If there are issues to be addressed, we will look into them," he said.

All in all, Husaini feels that the habit of not littering is of paramount importance to keep the city free from floods. Unfortunately, drains, rivers and their tributaries are often choked with rubbish.

"Public awareness is essential, and we are improving on that through the 'River of Life' outreach programme, which has in general received very encouraging responses so far," he said.

from qualified international companies for the Makkah Metro.

Al Bar told the Saudi Arabic language daily Al Youm that a letter containing the terms and specifications of the project has been sent to the pre-qualified 10 consortia vying for the first phase of the project involving civil works.

"We have asked them to submit their bids for this project. We intend to sign the contract with the winning bidders in early October," he said.

Al Bar said the project involves the construction of 88 train stations, including 22 underground depots, adding that six consortia have been pre-qualified to bid for the buses project, which is also part of the city's general transport scheme.

He said four rail lanes stretching around 182km would be constructed within the project to ensure coverage for the entire Western city of Makkah (also known as Mecca).

"As for operation and maintenance, this project is now under way. We have already contracted with a consultancy firm to manage the metro project and another one for the design of bus lanes.

"Both of them are now working on their projects," he said.

The Saudi cabinet has approved the metro project, part of an ongoing transport modernisation scheme through the Kingdom, at a total expected cost of USD 16.5bn.

DOTC finalising Philippines Metro plans

Philippines The Department of Transportation and Communications (DOTC) is finalising the alignment of the ambitious PHP 135bn (USD 3bn) subway or underground rail system dubbed as the Mass Transit Loop System, according to local media reports.

Metro bus project calls for building tunnel in twin cities

Pakistan A seven-storey metro bus terminal would be built near Flashman Hotel in Sadar, Rawalpindi, Pakistan, in respect of the Rawalpindi-Islamabad metro bus project, according to local media reported last month.

The first three floors would be allocated for parking while a control room would be built on the fourth storey to monitor the 22.5km long metro bus track an 8.6km elevated corridor in Rawalpindi and 13.9km on the ground in Islamabad.

High-tech close circuit cameras would be installed at the bus stations on both sides of the track.

Moreover, foolproof

security system would be put in place.

An underground tunnel would be constructed from D-Chowk to the Secretariat. Some areas of the Peshawar More would also be made part of the tunnel.

Underpasses would be constructed throughout the Blue Area.

The Blue Area bus station would also be built underground.

This contract has been awarded at the cost of MYR 39 billion (USD 12.4 billion), and 5 January 2015 has been set as the deadline for total completion of the project.

In the first phase, some 60 buses would be plied on the metro bus project routes and 153,000 commuters would travel by these buses daily.

Makkah Metro deal expected in October

Saudi Arabia Saudi Arabia has asked 10 of 16 international consortia to submit their bids for the multi-billion dollar Makkah Metro project and the contract will be signed in early October, according to the city's mayor.

Mayor Osama Al Bar said the project would be launched in mid-2015 and would be operated on a trial basis in 2017 before it is fully commissioned at in early-2020.

Last month Emir of Makkah, Prince Mishal Bin Abdullah, who is the chairman of the 'Authority for Development of Makkah and the Holy Sites', approved inviting bids for supplying locomotives and coaches



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JCM launches first Northgate Link TBM in Seattle

USA The first of two TBMs that will dig new twin light rail tunnels from the Northgate neighborhood in Seattle to the University of Washington began mining on July 9.

The machine will mine approximately 3.5 miles from the tunnel portal just south of the Northgate Transit Center to UW where the tunnels will connect with the University Link line into downtown Seattle.

That section between downtown and the UW is scheduled to open in early 2016.

These tunnels are being constructed by the same contractors, Jay Dee Contractors of Livonia, Mich., Frank Coluccio Construction Company of Seattle, and Michaels Corporation of Brownsville, Wisconsin, that successfully completed two one-mile tunnels for the University Link light rail

project. The University Link light rail project is currently scheduled to open in the first quarter of 2016, six to nine months early, and is estimated to be completed approximately USD 150M under budget.

The USD 2.1bn Northgate extension includes underground stations in the U District and Roosevelt neighborhoods and an elevated station at Northgate.

The extension is expected to add more than 60,000 riders a day to the system by 2030.

A second TBM is being assembled at the Northgate site and is expected to begin mining the second tunnel in October.

Crossrail chief says worker who died in tunnel "shouldn't have been where he was"

Great Britain Crossrail chairman Terry Morgan has said that the death of a Crossrail construction worker on the London project

happened because "the individual went into an area that was excluded".

Speaking to London Live, Morgan said that Crossrail bosses still do not know why the man went into the area, though they do know how he died.

The worker, identified after the incident by police as Rene Tkacik, a 43-year-old Slovakian national, was spraying concrete onto an area of excavated ground when another piece of concrete fell onto his head from the ceiling.

Police officers, three fire engines, over 50 firefighters and ambulance crews attended the scene of the accident on 7 March this year, but Tkacik was pronounced dead at the scene.

He had been working 10m down a tunnel at the time, building a new crossover between two main train tunnels already constructed by the Crossrail boring machines.

Morgan said: "It is a very difficult working environment

as you can imagine, this particular individual was on a work site doing a very careful job in terms of what we call spray concrete on the walls we were building.

"This individual went into an area that was excluded, shouldn't have been in there and we're still trying to understand why it happened.

"As far as we are concerned this should not have happened."

Government official reveals operator selected for Sydney's NWRL

Australia NSW Premier Mike Baird and minister for Transport Gladys Berejiklian today announced the AUD 8.3bn (USD 7.7bn) North West Rail Link has reached its most important milestone yet, with a preferred operator selected to run the new rapid transit service.

Baird announced the Northwest Rapid Transit consortium has been selected as the preferred operator to deliver the project's operations contract.

"The NSW Government is getting on with the job of building the North West Rail Link, Australia's biggest public transport project and the first stage of Sydney Rapid Transit, Sydney's brand new rail network."

Baird added: "This is a landmark moment for the North West Rail Link and the NSW Government will now work with the Northwest Rapid Transit consortium to further negotiate and finalise this multi-billion-dollar contract, which is expected to be awarded later this year."

The consortium is made up of: MTR Corporation (Australia), John Holland, Leighton Contractors, UGL Rail Services and Plenary Group.

The North West Rail Link calls for 15km of twin tunnels with 60 per cent of boring to be through Sydney Sandstone and the remainder through shale.

SECOND TUNNEL PACKAGE AWARDED FOR PARIS METRO'S LINE 14 EXTENSION

France A consortium consisting of Bouygues Travaux Publics, a subsidiary of Bouygues Construction, Soletanche Bachy France, Soletanche Bachy Tunnels and CSM Bessac has signed a contract worth EUR 164.9M (USD 224.4M) with RATP for the second tunnel package of the Paris metro line 14 extension project, north of Paris, running from Clichy-St Ouen to Pleyel, in the neighbouring town of St Denis.

This underground infrastructure project, which is 55 per cent financed by Société du Grand Paris, is expected to relieve congestion on Line 13, improving travel conditions and access to Paris for people living in the northern suburbs.

The consortium will be responsible for constructing a 2.2km tunnel linking Clichy-St Ouen and Pleyel, including a tunnel that links to the train maintenance and marshalling zone. It will also include the construction of the Mairie

de St Ouen station, and four ancillary structures, including reinforcing the infrastructures of line C of the RER (Regional Express Network).

The project, which will be carried out with an 80m long EPB machine, includes several major technical challenges, such as taking account of the diversity of soils along the route of the tunnel and the reinforcement of the infrastructures of line C of the RER, beneath which the connecting tunnel to the train maintenance and marshalling zone will pass.

To meet these challenges, the consortium will analyse all the data collected from the TBM and resulting from monitoring on the surface in real time in order to have the capacity for immediate response.

The works will begin this summer and last several years, mobilising nearly 260 employees at peak periods. The companies in the consortium have undertaken to hire site workers through social inclusion schemes.

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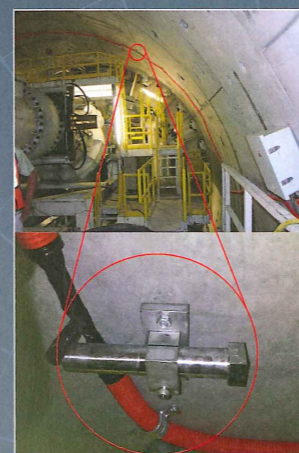
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Typical installation of the RST Profile Monitoring System for Tunnel Concrete Segments with an RST flexDAQ Datalogger System.



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FRENCH FIRM WINS CONTRACT TO DESIGN JEDDAH METRO

Saudi Arabia The Saudi government has signed a SAR 276M (USD 73.6M) project with a French firm to provide preliminary engineering designs for its public transport metro project in Jeddah.

The agreement was signed on 17 July with the company Systra for a period of 20 months, according to local media reports. The company would look at all previous plans and come up with a new one, according to the reports.

Those present at the signing ceremony

included Prince Mansour bin Miteb, minister of municipal and rural affairs, and member of the Jeddah transport higher committee, Jeddah Governor Prince Mishaal bin Majed and Makkah Governor Prince Mishaal bin Abdullah, president of the Jeddah transport higher committee.

After signing the contract, Prince Mishaal thanked King Abdullah and Crown Prince Salman for supporting the project and helping to improve the lives of citizens.

He urged the consultancy firm to make every effort to provide the best designs for the metro, to meet the aspirations of the country's leadership.

He also thanked Prince Mansour for his efforts in following up on this vital project and ensuring that other important projects in Makkah run according to plan.

Prince Mishaal said the project would be one of the most important in the country because it would improve public transport and reduce congestion.

Fourteen rescued after 131 hours underground

China Fourteen workers were rescued from a railway tunnel collapse in southwest China's Yunnan Province in the early hours of 20 July after more than five days trapped underground, Xinhua News Agency reported.

One person remains missing and the rescue operation continues.

Onlookers cheered and applauded in as the 14th trapped worker was brought out of the tunnel at 2:58am on 20 July.

Ambulances waiting at the entrance to the tunnel immediately took the survivors to the People's Hospital in Funing County, where the tunnel is located.

"They look OK, but need a thorough examination. Plus we believe they will need psychological counselling later. We have made plans to help them recover," said Xu Heping, the deputy chief of the provincial health department.

The about 20 meters of the 13.5km tunnel collapsed at around 4pm on 14 July. More than 400 rescuers worked to free the trapped men.

At 7:20pm on 15 July, rescuers managed to drill after more than 27 hours of rescue work and sent food, water and flashlights to the workers inside, while

they tried to remove the obstructions. The trapped workers helped to fix the broken electric wires on Wednesday (16 July 2014) and the power supply to the trapped area resumed.

However, in the following days, the rescue operation suffered a major setback as the drilling machine broke down, said Wang Jingjiang, deputy general manager of the railway company that runs the tunnel.

Using smaller rigs avoided tough obstructions, but slowed progress. A small tunnel was finally opened up on early 20 July morning, said Wang.

Investigation into the cause the accident is underway.

EPBM chosen for Chalco Valley project

China A giant canal tunnel will be built using an EPB tunnelling machine in Mexico's Chalco Valley over the next three years, following the contract being awarded earlier this year to Mexico-based construction company, Empresas ICA.

The 7.9km, 5m diameter tunnel will run parallel to the General Canal, from the Parada del Toro pumping station to the La Caldera pumping station. The project, which will use an EPB machine for the excavation, includes fabrication and

installation of the pre-cast concrete segmental lining, installation of the finish lining and covering, and construction of four 12m diameter drop shafts, with an average depth of 25m each.

The works will be executed over three years and are an integral part of Conagua's long-term plans to help reduce the risk of seasonal flooding within the Chalco Valley.

Empresas ICA secured the USD 860,000 contract from the national water commission, Conagua, to construct the General Canal Tunnel in the Chalco Valley, Mexico.

Nanjing Metro opens two new lines

China Nanjing Metro Line 10 and suburban line S1 to the airport in the capital of Jiangsu province in Eastern China opened on 1 July.

Line 10 was built as a 15.9km Olympic Stadium - Yushanlu extension of Line 1's 5.7km Andemen - Olympic Stadium branch, which it has now absorbed.

Line 10 has one elevated and 13 underground stations, and an end to end journey time of around 40 minutes.

The 35.8 km Line S1 was originally planned as metro Line 6. It connects Nanjing South station with Lukou International Airport. A 50km second phase from

the airport to the Gaochun district is scheduled to open in 2015.

Monas underground parking lot construction to begin next year

Indonesia Jakarta City Administration plans to utilise the National Monument's (Monas) underground space in the immediate future.

Gamal Sinurat, Head of the Spatial Planning Agency, said on 9 July that the underground construction of Monas will begin next year.

At this moment, the construction plan has entered the revising master plan design phase and detail engineering design (DED) phase.

"Back then when the governor was still on duty, DED and master plan direction were revised by an appointed consultant," said Gamal. Moreover, he said that the revision can be finished in the next two to three months.


Gamal said that the construction of the Monas underground facility (parking lot) will be funded by the regional budget.

However, he refused to provide detailed information. He also made it particularly clear that the construction works will not disrupt Monas, reassuring the public that modern tunnelling technology is sophisticated.

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**Klang Valley MRT Line
Two decision eagerly
awaited**

Malaysia Mass Rapid Transit Corporation (MRT) hopes a decision on Line Two of the Klang Valley Mass Rapid Transit (KVMRT) project will be made soon as it wants to immediately deploy resources to it from Line One, which is more than 40 per cent completed.

"We hope that a decision on Line Two will be made soon so that we can deploy the learning curve and resources from Line One and not waste them.

The faster Line Two starts the better, as Line One is progressing well. "The ball is in the MOP's (Ministry of Finance) court," MRT Corp. chief executive officer Datuk Azhar Abdul Hamid announced in Kuala Lumpur on 30 June.

According to Azhar, 45.59 per cent of Line One has been completed as at 31 May.

He said seven more contracts worth slightly below MYR 1bn (USD 310M) will be given out this year, bringing the total value of jobs awarded to MYR 23bn (USD 7.17bn).

MMC-Gamuda JV – a 50:50 joint venture between Gamuda Bhd and MMC Corp Bhd – was appointed as the project delivery partner (PDP) for Line One in January 2011. It also won the MYR 8.2bn (USD 2.56bn) tunnelling job.

As a PDP, it will receive a six per cent fee of Line One's total contract value.

Should the total cost of the project be less than or equal to the targeted cost, the PDP will be entitled to the full fee.

However, if the project cost is more than the targeted cost, the fee will be cut in accordance with the agreed formula.

A PDP's top priority is to ensure the successful completion of mass rapid transit lines within the pre-determined target cost and date.

In the event a contractor or a subcontractor does not meet the pre-determined work package requirements, the PDP will step in at no risk to project delivery cost and time.

On Line Two, Azhar said it will also be implemented based on the PDP concept and opened to the private sector.

"The government has said Line Two will be done based on a PDP concept and it is its call on who it wants," he said.

MRT is the implementation agency and asset owner of the KVMRT, which comprises three lines estimated to cost around MYR 80bn (USD 25bn).

Line One, which is under construction, is from Sungai Buloh to Kajang.

Line Two will comprise the north-south line from Selayang to Putrajaya, while Line Three is the circular, orbital line that will loop around the Kuala Lumpur city centre.

It is understood that the Land Public Transport Commission has completed the alignment feasibility study for Line 2 and it is currently being reviewed.

New tunnel opens to traffic

Japan The Ogurasan Tunnel, a brand-new 2,100m tunnel, was officially opened to traffic on 28 June.

It forms part of a road link between the Sagami-hara-Aikawa Highway Interchange in the Kanagawa Prefecture

and Tokyo's Takao-san Interchange.

It will cut travel times between the two regions and form the basis of an ongoing autonomous driving test zone near Nissan's Global Headquarters, according to Kanagawa Governor Yuji Kuroiwa, who performed the inauguration ceremony.

Wuxi City in China's east opens first metro line

China The first metro line in Wuxi, a city of 6.3 million inhabitants in China's eastern Jiangsu province, was inaugurated on 1 July by the city's mayor Mr. Wang Quan.

Line 1 runs for 29.5km from Yanqiao in the north to Changguangxi in the south with 24 stations. Most of the route is underground, with only 7km on an elevated alignment.

Services are operated by a fleet of 23 six-car Type B metro trains supplied by CSR Zhuzhou, which accommodate up to 1,846 passengers.

An east-west Line 2, running from Meiyuan to Anzhen, is currently under construction and is scheduled to open in December.

It too will be mostly underground, with 6.5km on an elevated alignment out of a total length of 26.5km; the route will have 22 stations.

The city plans to ultimately construct a five-line network totalling 157.7km with 111 stations.

Hangzhou Metro running tunnels flooded

China A section of metro that is under construction in Hangzhou, capital city of east China's Zhejiang Province, flooded on 31 July, the state-run Xinhua News Agency reported.

Water was found leaking into the section between Jiangjin Road Station and Citizen Centre Station on Subway Line Four.

POSSIBLE NEGLIGENCE INVESTIGATED ON MALAYSIAN SINKHOLE INCIDENT

Malaysia Malaysia's Federal Territories Ministry is investigating whether there was negligence on the part of the contractor of an underpass project where a sinkhole occurred at the Jalan Imbi-Jalan Pudu intersection, in Kuala Lumpur on 2 July, Bernama (National News Agency of Malaysia) reported. Its minister Datuk Seri Tengku Adnan Tengku Mansor said stern action would be taken against the contractor involved if there is proof of negligence.

"The soil instability was caused by a burst Syabas (Syarikat Bekalan Air Selangor) pipe, resulting in the cave-in," he said.

He was asked to comment on the cave-in incident at the underpass project under Kuala Lumpur City Hall which left a big, deep hole at

the road intersection. In the 9.30am incident on 2 July, part of the 35m underground tunnel which is under construction for four vehicle lanes to ease congestion at the Jalan Imbi intersection, collapsed to a depth of 5m following soil movement.

Tengku Adnan said remedial work was going on, including pumping soil and cement to stabilise the affected area, besides checking the Monorail track which was affected by the cave-in incident. "We hope it will be completed in two weeks," he said. The minister said the incident was unavoidable, but he reminded contractors carrying out underground works to be extra careful and to study the site condition first in order to prevent any untoward incident.



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LOK HOME NAMED INDUSTRY OUTSTANDING INDIVIDUAL

USA The USA's Underground Construction Association (UCA) presented Lok Home, president of The Robbins Company, with its the Outstanding Individual Award. The distinguished award is given to a person who has made major contributions to the tunneling industry throughout their career and is presented at its annual awards banquet, held in conjunction with the North American Tunnel (NAT) Conference.

David Klug, President of David R. Klug & Associates, and past UCA chair, said in his presentation of the award: "We nominated [Lok Home] not only for his work in the industry as a manufacturer, but also for his work to promote the industry as a whole."

A Robbins spokesman said, "Home was nominated in large part because of his work to promote the industry by bringing the ITA-AITES World Tunnel Congress (WTC) 2016 to the United States. The event will be held in San Francisco, California in collaboration with NAT, marking 20 years since the last WTC conference

was held in the U.S. The bidding process to bring the WTC to San Francisco required an extensive time commitment and industry knowledge."

Klug added, "We needed someone who understood the international community, and was well-respected throughout the world, to manage the bid. Lok offered services from his company and staff to prepare the bid, and we won [the vote] at WTC Geneva."

Home began his tunnelling career over 45 years ago, after graduating with a degree in mining technology from the Haileybury School of Mines in Ontario, Canada. After working for several years in Canadian mines, he joined Robbins as a Field Service Manager. Home later founded Boretac, Inc., which acquired Robbins, and unified the two companies under the Robbins brand.

Upon receiving the prestigious award, Home attributed his success to the people he works with. "When it comes down to it, success comes from your team," he said.

The acquisition remains subject to the approval of the local competition bureau.

The acquisition is part of Bouygues Construction's international strategy and illustrates the Group's ambition to continue its development in Canada on all aspects of the construction value chain.

Bouygues Energies & Services is already established in British Columbia via its subsidiary Bouygues Energies & Services Canada, which was set up in 2008 to oversee the Facilities Management of two PPP projects in Surrey, Vancouver: the Jim Pattison Outpatient Care and Surgery Centre and the headquarters of the Royal Canadian Mounted Police's E Division.

Bouygues Energies & Services has also been providing Facilities Management at Kelowna International Airport in British Columbia since 2013.

Jean-Philippe Trin, Chairman and CEO of Bouygues Energies & Services, declared: "Canada currently offers high-yield short-term and long-term economic opportunities.

"Beyond Facilities Management and Mechanical & Electrical Engineering, we would like to take advantage of the excellent positioning of Plan Group in order to deploy our expertise in terms of HVAC, network infrastructures (HV lines, substations, street lighting, broadband), solar and biomass power plants."

Bouygues Energies & Services has proposed to Plan Group a business plan that creates the best conditions to develop its activities, together with a strong commitment towards the Plan Group employees.

After financial close, Bouygues Energies and Services will have acquired a 85 per cent stake of the shares of Plan Group.

The current management team will remain unchanged and will retain the remaining 15 per cent shareholding.

Garrod inducted into Canadian Academy of Engineering

Canada On June 26, the Canadian Academy of Engineering announced that Brian Garrod, deputy practice Leader for tunnels at Hatch Mott MacDonald (HMM) has been inducted as one of 49 new Fellows of the Academy.

Founded in 1987, the Academy is the national institution through which Canada's most distinguished and experienced engineers provide strategic advice on matters of critical importance to Canada.

According to the Academy, "Brian Garrod has played a pivotal role in some of the most challenging and innovative tunnelling projects of the past several decades: the Channel Tunnel, Boston Harbor Outfall, Dulles Airport tunnel, San Francisco's BART extensions and TTC's [Toronto Transit Commission] Sheppard Subway.

"From this background he has helped establish tunnelling in North

America as a cost-effective, predictable and safe construction practice, as is demonstrated by the portfolio of recent and current tunnelling projects in Southern Ontario: OPG's [Ontario Power Generation] massive new Niagara Diversion Tunnel, the Spadina Subway Extension, York Region's Southeast Collector tunnels, Metrolinx's Eglinton Crosstown subway, and Metro's Coxwell Bypass, as well as the long-awaited pedestrian tunnel to Toronto's Billy Bishop Airport."

Earlier this year, Garrod was awarded the prestigious Ontario Professional Engineers Engineering Medal - Engineering Excellence Award. The award is jointly approved by the governing Council of Professional Engineers Ontario (PEO) and the Board of Directors of the Ontario Society of Professional Engineers (OSPE).

Nick DeNichilo, president and CEO of HMM said, "Brian Garrod is one of our most

prominent and accomplished engineering professionals, and we are gratified to see him receiving the recognition he deserves."

Garrod has 41 years of general civil engineering experience, the last 29 years devoted solely to transit and tunnelling assignments.

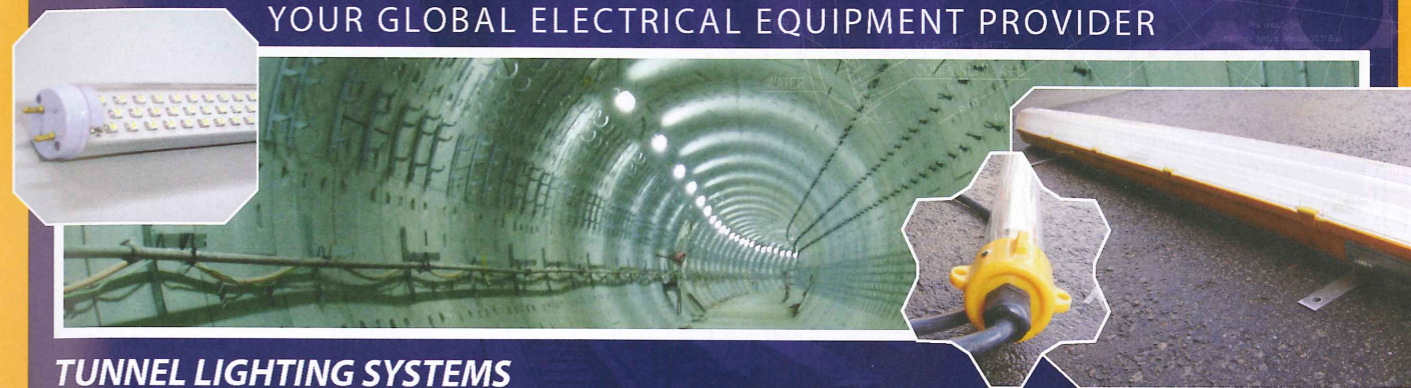
Bouygues Energies & Services acquires Plan Group of Canada

Canada Bouygues Energies & Services, a subsidiary of Bouygues Construction, has acquired a majority shareholding in Plan Group, a Canadian technical services provider. It operates in mechanical and electrical contracting, maintenance and technical services, building automation systems and the network infrastructure sectors.

Based in Toronto, Ontario, as well as Ottawa, Montreal and Vancouver, Plan Group achieved a turnover of CAD 361M (USD 335.75M) in 2013 and has an employee base of around 1,700.

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BIRKENHEAD TURNS 80

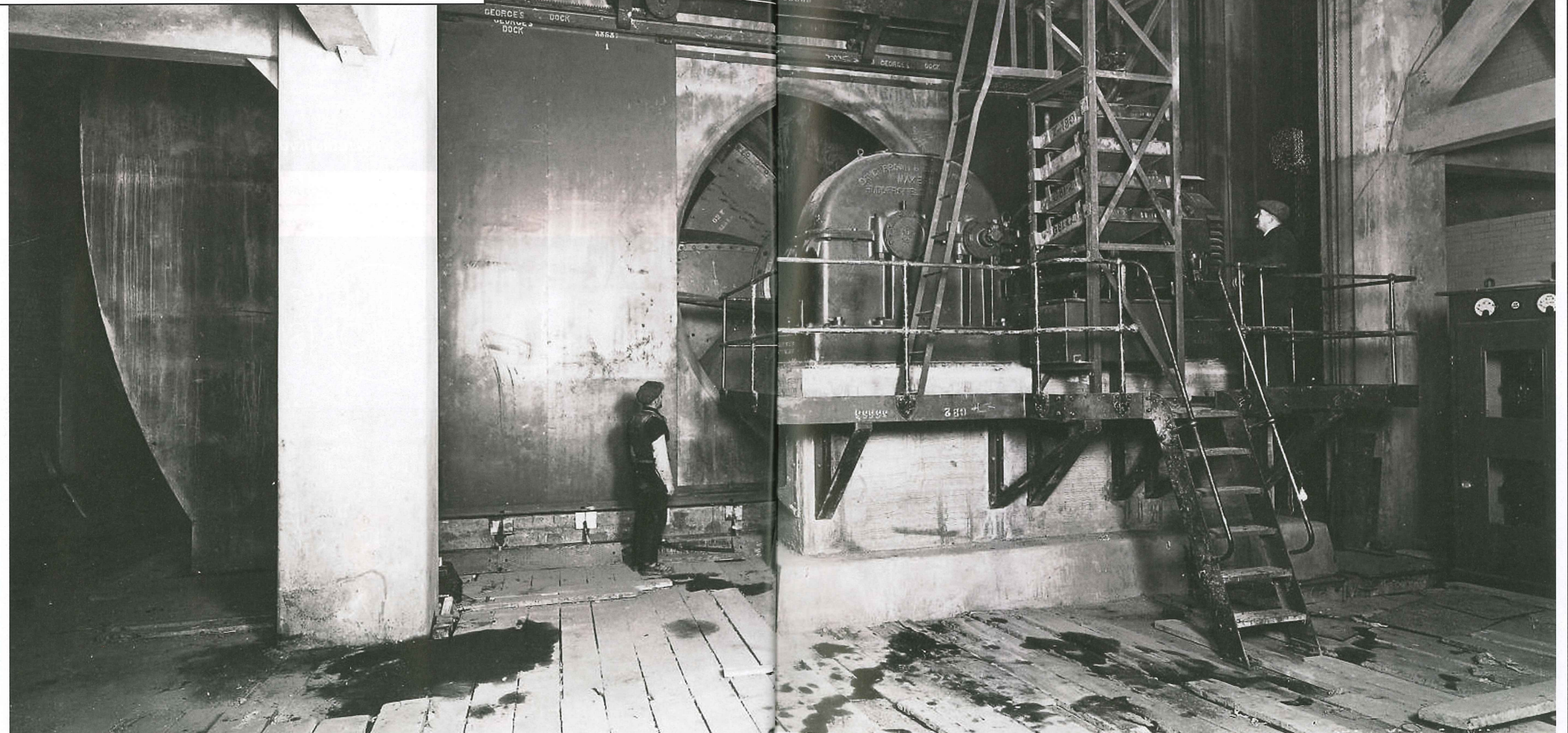
The 80th anniversary of the Queensway Tunnel in Liverpool, UK was marked last month. The tunnel was the first road link under the River Mersey, and took almost nine years to build, with work starting in 1925. King George V opened the 2.13 miles (3.45km) link, also known as the Birkenhead Tunnel, on 18 July 1934.

Tunnelling cost GBP 8M at the time, and 1,700 men worked on the project. Over 1.2Mt of rock and gravel were excavated, while 82,000t of cast iron and 270,000t of concrete were installed. The ventilation fans (pictured) weigh 25t.

The Queensway (Birkenhead) and the Kingsway (Wallasey) tunnels are major thoroughfares, with approximately 25 million vehicles travelling through them each year.

The tunnels are, according to Merseytravel, regarded as the safest tunnels in the UK and amongst the safest in Europe for their age following the last independent assessment.

Merseytravel delivers transport projects in the Liverpool City Region and functions as an executive body that provides professional, strategic and operational transport advice to local government.



Going further in 2014

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EASTERN PROMISE

Previously driven by the oil and gas sector, tunnelling in the Middle East is enjoying a new boom as metro systems and new sewer networks are developed throughout the region. **Bernadette Ballantyne** reports

FROM NEW metros in Riyadh and Doha to super sized sewers in Abu Dhabi and Bahrain and road tunnels and pipelines in Oman, the Middle East tunnelling sector is buoyant. And although it is busy now a lot more work is set to come. Cities around the region are all planning metros and using the third dimension will be critical as authorities seek to limit disruption above ground

Bernadette Ballantyne
Bernadette is a regular contributor to *Tunnels* and editor of *Underground Utilities*



Table 1. Tunnelling projects by country

Country	Value (USDM)
Qatar	27,850
Saudi Arabia	22,695
Oman	4,746
Mozambique	4,000
United Arab Emirates	1,600
Tanzania	900
Egypt	277
Israel	259
Kenya	120
Cape Verde	110
Nigeria	100
Lebanon	100
Morocco	70
Grand Total	62,827

Source: Timetric's Construction Intelligence Center

For some states mechanised tunnelling is a new proposition but success on schemes such as the metros in Cairo and Dubai and sewer project in Abu Dhabi are giving clients the confidence to bring in TBMs to deliver their infrastructure. Data from the Construction Intelligence Center and research by *Tunnels* shows that there are

Below: Qatari officials examine a Doha Metro TBM

over USD 63bn of tunnelling projects currently underway in the region driven by oil and gas, water and transport. This figure includes the enormous USD 22bn Riyadh metro scheme, which involves the simultaneous construction of six new metro lines, to be undertaken by three consortia. The full extent of the tunnelling requirements on this project is yet to be revealed but in all there will be 175km of new light rail laid throughout the city. Major development contracts were awarded in mid 2013. Lines One and Two will be delivered by the BACS consortia consisting of US Bechtel, Saudi Arabia's Almajani, Athens headquartered contractor Consolidated Contractors Company (CCC) and Germany's Siemens. The overall contract value is approximately USD 10bn.

Line Three running over 40km will be delivered by the Riyadh New Mobility Consortia which consists of two groups. The electrical and mechanical equipment for the driverless metro will be delivered by the Electrical Works Group (EWG), whose members are Spain's Ansaldo STS and France's Bombardier; and the systems infrastructure is being delivered by the Civil Work Group (CWG) consisting of Italy's Salini-Impregilo, India's Larsen & Toubro and Saudi Arabia's Nesma.

Lines Four, Five and Six are to be developed by the FAST consortia led by Spanish contractor FCC with South Korea's Samsung, France's Alstom, Strukton from The Netherlands, Freyssinet Saudi Arabia and engineering consultants Tyspa from Spain and French firm Setec. The contract is worth USD 8.2bn.

FIRST AMONG EQUALS

But for now the biggest scheme under construction is undoubtedly the Qatari capital of Doha's metro which has seen the procurement of 21 earth pressure balance tunnel boring machines from Germany's Herrenknecht (see Doha



Automated metros dominate

Public transport users in the Middle East would be forgiven for thinking that all metro systems are fully automated. Certainly anyone who has ridden the GCC's first mass transit system, the Dubai metro will be used to contactless ticketing, platforms where sliding protective doors open at just the right time to meet the open doors of the carriage, real time journey information displayed on screens in the carriage and driverless trains which move smoothly between stations.

However the first systems in the world were manually operated and over time automation has increased as cities such as London, New York and Paris have added to and upgraded their networks. This has led to a range of operating modes from partly automated where drivers control braking and acceleration but a train protection system monitors speed; to semi-automated where drivers start the train but the automatic driving system controls movement between stations; to fully driverless unattended metros, which is known in the industry as unattended train operation (UTO). Today Dubai is actually the longest UTO system in the world with some 75km of track just ahead of Vancouver in Canada with 68km.

French systems supplier Thales Group provided the technology that enabled Dubai to take a world leading position on metro operations. Its SelTrac communications based train control (CBTC) solution is in use on red and green lines, which form part of its 900km portfolio. According to Thales Rail, there are another 370km of lines currently under construction that are also set to use this system.

In terms of the systems themselves CBTC consists of a number of core elements that are the same wherever the metro is. Trackside computers monitor assigned sections of line calculating a 'movement authority' to set permissible distance between trains. In Dubai this is 90 seconds. The trains themselves are operated using automated train control (ATC) which uses on board and trackside data to ensure safe and efficient service. The main components of this are the automated train operation (ATO) system which performs the driver functions such as ensuring smooth braking and acceleration, and the automatic train protection system (ATP) which sets the speed limits and interacts with the signalling system. This is all monitored in operation rooms at the stations and at a central Operational Control Centre (OCC).

Modern systems run wirelessly using radio based technology, although this was not always the case and train control technology has improved since it was first introduced in the 1980s. Early systems used cable loops to communicate between the train and the track and axle counter or track circuits to separate the track sections. The track was divided into fixed

blocks along the track where only one train was permitted at any one time. The authorisation was transmitted via loop to notify trains travelling behind when the section was clear allowing the next train to move forward. However by the late 1990s the approach had evolved with systems using wireless communication to monitor the position of trains relative to each other. By 2000 a lot of research had been done into replacing the loop with radio and the first was commissioned on the Canarsie Line in New York. Experts say that driverless systems have many benefits. "Driverless systems provide greater capacity, more efficient running, reduced operational costs and improved punctuality," says Mohammed Garda, manager of consultant Mott MacDonald's railways business in the Middle East. "Most new metros now include a level of automation with the trend firmly being a driverless system."

According to the International Association of Public Transport there are currently 674km of driverless systems worldwide over 48 lines and 40 per cent of these are in Asia.

Garda says that the main concern for the public with any automated system is whether the same level of safety can be achieved when compared with a driven system. Automated systems need to have greater monitoring of the operational environment through the use of CCTV, radio contact with staff and alarms, especially those to detect any trackside intrusion. "In the event a train needs to be evacuated the infrastructure needs to be designed such that passenger movements to a place of safety can be undertaken quickly and without panic," says Garda.

One of the biggest issues is preventing any intrusion onto the track and this has led to the widespread adoption of platform screen doors at stations which encloses the platform environment minimising the potential for track access.

As the Gulf moves forward with its new schemes there are some operational considerations that regional UTO systems will need. The aggressive heat means that the sophisticated computer systems on board the trains, trackside and stations should be protected through the use of temperature controlled environments, redundant systems and health monitoring alarms. "Sand in the air has to be filtered and cleaning needs to part of the maintenance regime for sophisticated electronic systems," says Garda.

From these technical issues to the tight deadlines, the region is certainly presenting challenges along with the massive opportunities that the next decade promises. But the systems are proven at a global level, and now thanks to Dubai and Mecca at a regional one and driverless trains are set to become a feature of most of the Gulf's major cities which have made mass transit a priority.

feature, p.28). Between them the machines will excavate 113km of the emirate's soft ground made up of Simsina limestone, Rus Formation and shale, creating three new metro lines in the process. And this is just the first phase of the scheme with the lines being extended and a new blue line added by 2026.

For the Gulf these new metro schemes owe much to the local pioneer of light rail, the Dubai metro. The first 52km red line opened in September 2009 and the second, 23km green line opened in September 2011. The contractor consortium was led by Japan's Obayashi Corporation, with Kajima Corporation, Mitsubishi Heavy Industries and Turkey's Yapi Merkezi.

Despite experiencing cost and time overruns the project remains a major achievement for a region with no previous

experience of TBMs or light rail. Of the first 70km of light rail system, 13km were tunnelled using three 9.56m diameter Mitsubishi EPBMs over ten separate drives.

Plans for extensions of the metro were put on hold as Dubai weathered the financial storm battering its state owned development companies and affecting governmental infrastructure spending, however the award of the World Expo 2020 has given a renewed impetus to the project. France's Systra with US Parsons International are

currently doing preliminary engineering for a new line out to the Expo site, which is adjacent to Dubai's new Al Maktoum International Airport.

STEP

More recently however tunnelling activity has been focussed in neighbouring Abu Dhabi, which along with plans for its own light rail system, is nearing the completion of its new sewer network. Known as the 'strategic tunnel enhancement programme' (STEP), it is designed to replace the existing pumped wastewater network with a new gravity sewer system. A total of six contracts were awarded including three for the main 41km sewer, two for the connection pipework and one for a new pumping station. Tunnelling was achieved using 8 TBMs on 5km bores delivered in three contracts.

Upon introducing the project to the market in 2008 the scheme attracted over 45 expressions of interest and this was narrowed down to a list of 15. In September 2009 Italy's Impregilo became the first contract winner, securing the AED 891M (USD 243M) contract for package T02. Involving three major work shafts, three additional access shafts and a total of 15.5km of tunnelling this section formed the centrepiece of the sewer and ranges in depth from 43m at the north end at work shaft five (WS5) to 61.9m at the southernmost point work shaft seven (WS7).

The deepest section of the sewer was also awarded to Impregilo, this time in November 2010. The contract involved construction of work shafts eight and nine and a 9.7km bore between them. The deepest shaft, number nine goes down to 79.7m. This drive is slightly larger than T02 with a 6.98m external diameter providing space for a finished internal tube of 5.5m diameter.

Both of these contracts are now complete with the final section, known



as T01, which was awarded to Samsung C&T Corporation in February 2011, due for completion at the end of 2014. It included construction of five work shafts, three access shafts and three major tunnel bores making up a total section length of 16.1km. "All 41km of deep tunnel have been excavated without a single incident - the last breakthrough was last October (2013)," says Robert Marshall, STEP programme manager for the US firm CH2MHill. "The two Dublin contracts (for link sewers) should be complete by mid 2015 - although we have been given an additional 3.1m internal diameter section of link sewer connecting Al Reem Island into the system, which will extend the completion of Contract LS-01 to the end of 2015. We have nine TBMs of varying sizes on the link sewers, so with the eight TBMs on the deep tunnel contracts, we have used a total of 17 TBMs on the job."

So successful has Abu Dhabi's experience been that Qatar is also using a similar strategy for its own super sewer, better known as the Inner Doha Resewerage Implementation Strategy (IDRIS). Once again CH2MHill is programme manager for the 40km sewer and 70km of link sewers which will serve the south of Doha. Like Abu Dhabi the scheme will use a single major pump station to transfer flows and requires a new wastewater treatment works to treat the sewage. The project budget is in excess of QR 10bn (USD 2.7bn). The eight year project is set for completion in 2019 and to date several major firms have been prequalified for the main trunk sewer which like Abu Dhabi has been split into three packages.

According to data from the Construction Intelligence Centre Qatar has the largest volume of tunnelling underway in the region at the moment, mainly thanks to its metro. The overall tunnelling market is estimated at USD 27.9bn and according to CIC the forecast compound annual growth rate in construction to 2017 is eight per cent per annum. This is closely followed by Saudi Arabia, again strongly boosted by Riyadh's metro. However other metros are getting underway which will see other markets gain in value. Amman (Jordan), Kuwait City, Baghdad (Iraq) and Tehran (Iran) and Jeddah (Saudi Arabia) are all planning metros and are expected to require large tunnelling elements.

With so many projects planned and several underway it is no wonder that the industry is excited about the regional opportunity. From microtunnelled link sewers to EPBs for new metros the market in the Middle East remains busy

Table 1. Tunnelling work by sector

Sector	Value (USDM)
Railways	22000
Railway	20959
Oil & Gas Pipelines	8350
Roads	6798
Sewers	4450
Electricity Transmission Cables	200
Water Distribution	70
Grand Total	62827

Source: Timetric's Construction Intelligence Center



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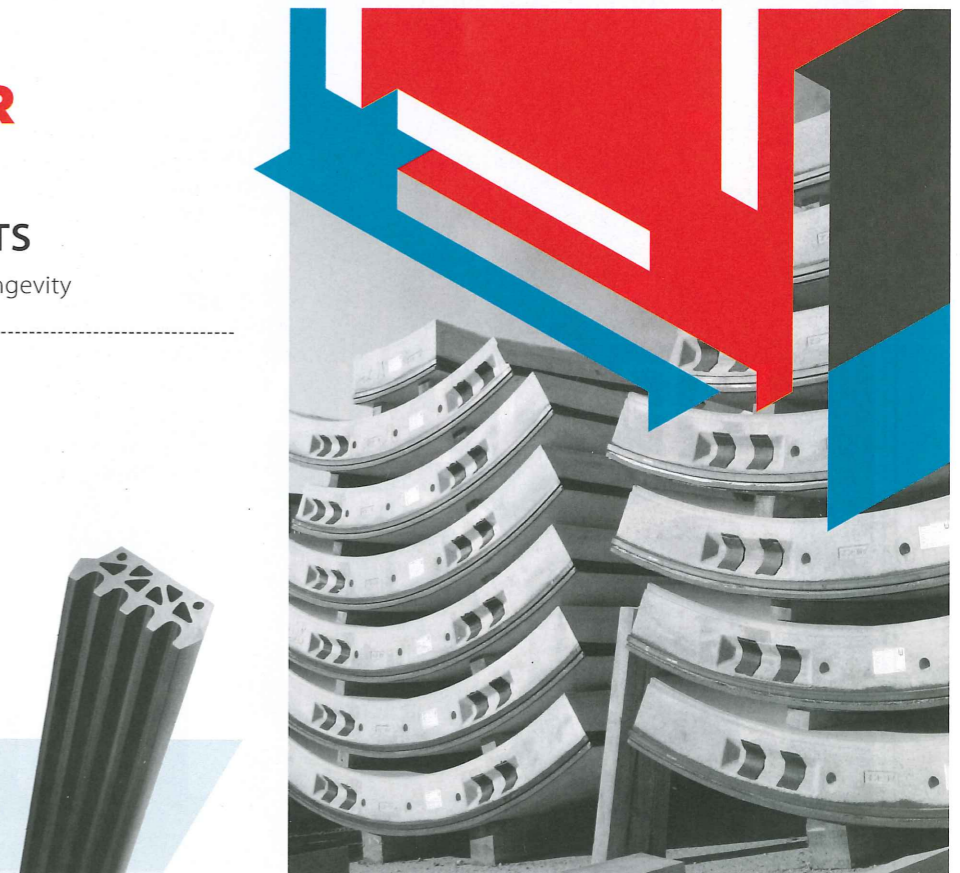
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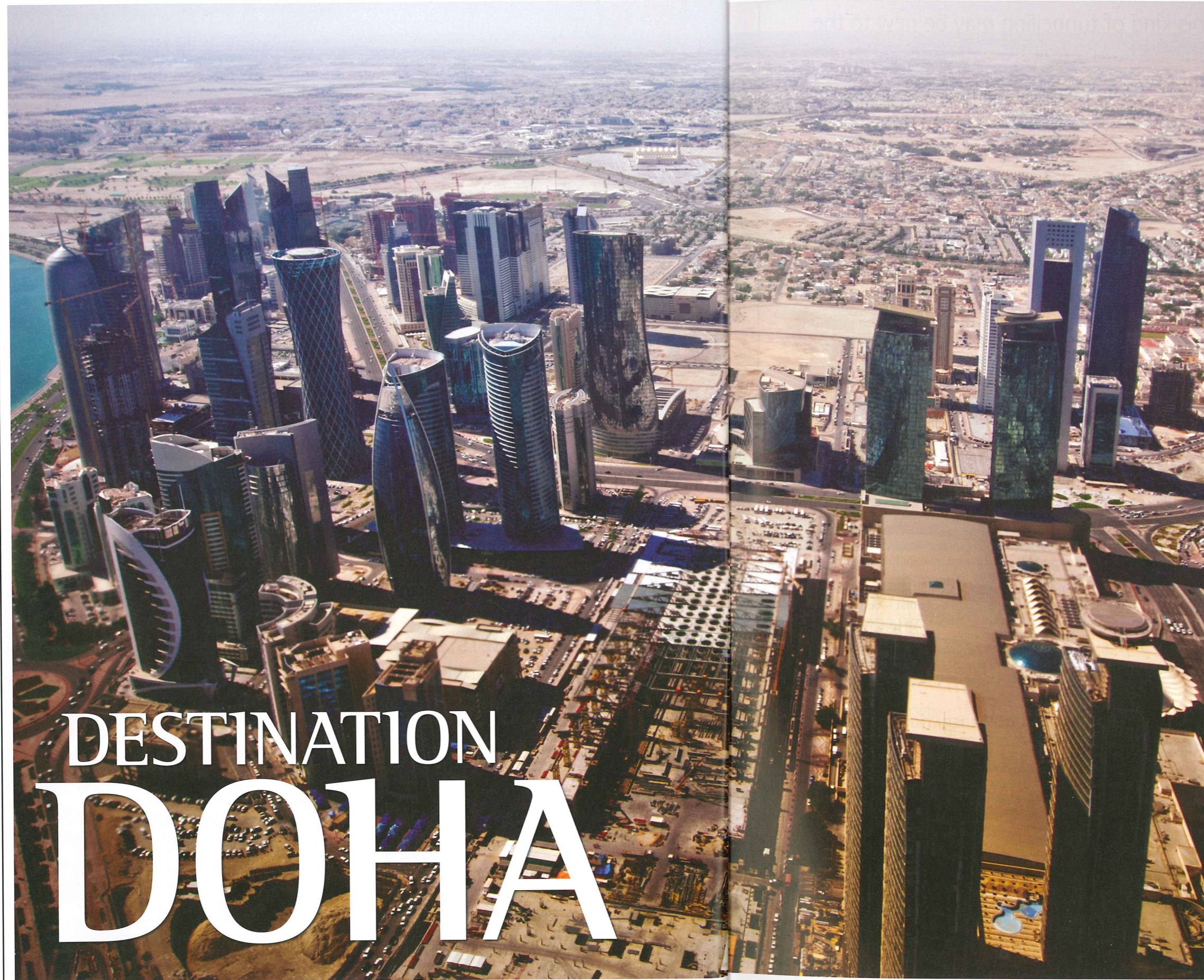
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DESTINATION DOHA

As tunnel boring machines continue to arrive in Doha, Tunnels and Tunnelling looks to find out more about the world's most ambitious metro scheme. Technical journalist Bernadette Ballantyne reports

ENSURING THE safe and timely arrival of 21 state of the art, EPBMs into the Gulf country of Qatar requires multinational cooperation and a pinch of good fortune. The majority of the journey sees the TBMs embark upon a month long ocean voyage as they are moved from Schwabau in Germany over to Belgium before beginning their Atlantic passage, which then takes them along the Mediterranean, the Gulf of Suez and into the Middle East before reaching their final destination of Doha. "The delivery of the new TBMs into Qatar had to go through a long logistic procedure. The TBM manufacturer, Germany's Herrenknecht, arranged the maritime transportation from the factories where the machines were manufactured in both Germany and China," explains Engineer Daniel Leckel, who is chief technical officer and chief programme officer at Qatar Rail. Upon arrival at Doha Port the operator Milaha Company enabled the discharge of the lorries carrying the TBM components on the enormous vessel. "Milaha's team was very cooperative with us and the Doha Port prepared some unique solutions to meet technical requirements for bringing the TBMs in," says Leckel.

"Qatar Rail's logistics team monitored the discharge of the machines from the vessels and accompanied the TBMs all the way to the dedicated construction sites where they are set to operate in Doha."

More coordination was also required between the logistics team and Qatar Customs Authority, to assist the contractors with the clearance procedures from the port. And of course conferences had to be held with the Traffic Police Department, for the assignment of the most appropriate roads from the port to the contractors' sites, and the scheduling of the police escort to guarantee a secure transfer of all machines.

Of course with the TBMs weighing up to 900 tonnes the EPB machines are split into 22 segments before being transported – and according to Herrenknecht the heaviest of these is around 64t. A ship sets sail from Antwerp every two weeks.

“The vessels are driving on a fixed schedule so we know that every two weeks the ship is going to Doha so we can optimise this. Each shipment usually takes between 28 and 31 days,” says Gerhard Wehrmeyer, division manager for traffic tunnelling at Herrenknecht, who also points out that there have been no storms or bad weather to delay shipping.

By June 2014 five of the 7.05m diameter EPBMs had arrived in Doha with a total of 21 set to be delivered in total. Between them this fleet of state of the art machines will bore the first phase of Doha’s planned metro system consisting of 115km of tunnels over three lines; Red, Gold and Green.

The first machine arrived in April 2014 and is being used by the consortia building the Red Line North. This involves 23km of tunnel excavation to be done with four machines and consists of contractors Italy’s Salini Impregilo, SK Engineering & Construction Co. from South Korea and Qatar’s Galfar Al Misnad Engineering & Contracting W.L.L. JV.

Named ‘Lebretha’ the first EPBM on site will travel approximately 8km over 22 months and is expected to complete its bore half way through 2016. Its average speed is forecast at 14 to 20m/day depending on the ground conditions, excavating around 5.4Mm³ during its journey.

Lebretha’s arrival was followed by four more machines: Al Mayeda, Al Khor, Lehwailla and Al Wakra which are also to be used on the Red Line, which has been split into two major contract packages: Red Line North and Red Line South. Al Mayeda and Al Khor will join the Italian led consortia on the northern packages and Lehwailla and Al Wakra will be used by the Red Line South team led by the French-Qatari company QDVC and comprising of South Korea’s G. S. Engineering and Construction and Qatar’s Al Darwish Engineering.

A total of five TBMs will be used on the southern section, which has 33km of tunnelling to undertake.

Bernadette Ballantyne

Bernadette is a regular contributor to *Tunnels* and editor of *Underground Utilities*



This kind of tunnelling may be new to the emirate but by pairing with internationals, Qatar will get a state of the art metro

NAMING TRADITION

Naming the machines gave the team an opportunity to ensure that the TBMs reflect the Qatari culture explains Leckel. “Since our TBMs will be operating across Qatar and since we are keen on integrating the Qatari culture in our operation system, we decided to name our TBMs after historical towns and cities, each carrying its own story and background,” he says.

Al Khor TBM, for example, operating at the Red Line North, is named after Al Khor coastal city in northern Qatar. Al Khor is known for its large concentration of modern and historical mosques and is home to the Al Khor Museum, as well as the city’s renowned Corniche and Port.

Al Zubara, for its part, operating at the Red Line South, was named after a town located north of the country. Dating back to the ancient 18th century, Al Zubara Fort in the town tells the story of its great history and remains a destination for visitors wanting to explore Qatar’s historical landmarks. “Naming a TBM after this remarkable town is a way preserving it and expressing appreciation to its value and heritage,” says Leckel.

The Doha TBM, also operating along the Red Line South, was named after the capital of Qatar, an urban and vibrant city, considered as the hub of Qatar State.

The name of Al Rayyan TBM, operating at the Green Line, refers to Al Rayyan district, embracing many landmark and historic sites. Besides having a distinguished heritage for being home of many ancient castles, Al Rayyan is also a hub for education, comprising a number of universities, colleges and institutes of the Qatar Foundation for Education, as well as Science and Community Development.

As for the Lusail TBM, operating at the Gold Line, it is named after the ultra-modern city that is becoming the most unique city in Qatar.

“The same concept applies to our 16 other TBMs, which are called Lebretha, Al Mayeda, Al Bidda, Lehwailla, Al Wakra, Mushaireb, Al Sheehaniya, Al Gharrafa, Al Messila, Leatooriya, Lijmayliya, Sharq, Al Sadd, Al Waab, Muaither and Al Sailiya,” says Leckel.

TECHNICAL CONSIDERATIONS

For the Doha project Herrenknecht has designed a new cutterhead to ensure maximum efficiency through the ground. “The solution takes into account Doha’s soft ground with Simsina limestone, Rus Formation and shale, the hydrology as well as other requirements of jobsite and customer,” says Wehrmeyer. “The design of the cutterhead with its openings, position and quantity of the different excavation tools was one important aspect for the Doha TBMs. The project specific and state-of-the-art design includes a sophisticated cutterhead center with a high opening ratio.”

For backfilling of the annular gap all machines work with bi-components consisting of the mortar and the accelerator sodium silicate.

GROUND ADAPTABILITY

That Qatar opted for an EPB shield model is not surprising



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Table 1. Project summary

	Red Line North	Red Line South	Green Line	Gold Line
Contractor	Salini Impregilo S.p.A./ SK Engineering Et Construction Co. Ltd./ Galfar Al Misnad Engineering Et Contracting W.L.L. JV	QDVC/ GS Engineering Et Construction Corp./ Al-Darwish Engineering W.L.L. JV	PORR Bau GmbH/ Saudi Binladin Group Company Ltd./ Hamad Bin Khalid Contracting Co. W.L.L. JV	Aktor S.A./ Larsen Et Toubro Limited/ Yapi Merkezi Insaat VE Sanayi Anonim Sirketi/ Sezai Turkes Feyzi Akkaya Marine Construction/ Al Jaber Engineering LLC JV
Tunnel in total	23 km	35 km	33 km	24 km
Machine	S-865 – S-868	S-860 – S-864	S-844 – S-849	S-920 – S-925
Shield Ø	7050 mm	7050 mm	7050 mm	7110 mm
Drive Power	1,280 kW	1,280 kW	1,440 kW	1,440 kW
Segments	6+1	7+0	5+1	6+1
TBM Length	120 m	140 m	120 m	120 m
TBM Weight	860 to	860 to	900 to	900 to
Gantry Length	110 m	128 m	110 m	110 m
Gantry	Tunnel belt conveyor	Muck car	Tunnel belt conveyor	Tunnel belt conveyor
Supply	Rolling stock	Rolling stock	Multi Service Vehicle	Multi Service Vehicle

The project specific cutterhead design involves a high opening ratio

for the limestone bedrock under Doha has a shale layer within it that may require closed mode operation. In poor ground the EPB Shields can use the excavated soil directly as support medium. The rotating cutting wheel equipped with tools is pressed onto the tunnel face and excavates the material. The soil enters the excavation chamber through openings, where it mixes with the soil paste already there.

Mixing arms on the cutting wheel and bulkhead mix the paste until it has the required texture.

The bulkhead transfers the pressure of the thrust cylinders to the pliable soil paste. When the pressure of the soil paste in the excavation chamber equals the pressure of the surrounding soil and groundwater, the necessary balance has been achieved.

A screw conveyor transports the excavated material from the base of the excavation chamber onto a belt conveyor for removal away from the tunnel face.

The interaction between the screw conveyor's throughput and the TBM's advance rate ensure that the support pressure of the soil paste can be controlled precisely.



Above: The client is looking for international expertise to help deliver the project

LOOKING AHEAD

Over the next few months the remaining TBMs will arrive in Doha and be distributed to the network of contractors that are creating Qatar's first major mass transit system in line with the aspirations of the country's strategic plan known as the Qatar National Vision 2030.

This kind of tunnelling may be new to the emirate but by pairing local contractors with the world's best tunnelling companies, Qatar is ensuring that not only will it get a state of the art system, it will get a sustainable one.

By the time the 2022 FIFA World Cup kicks off in Qatar locals and visitors alike will be using what is perhaps the largest metro ever to be built in a single phase and the 21 TBMs will perhaps have set sail again bringing the same benefits to other cities

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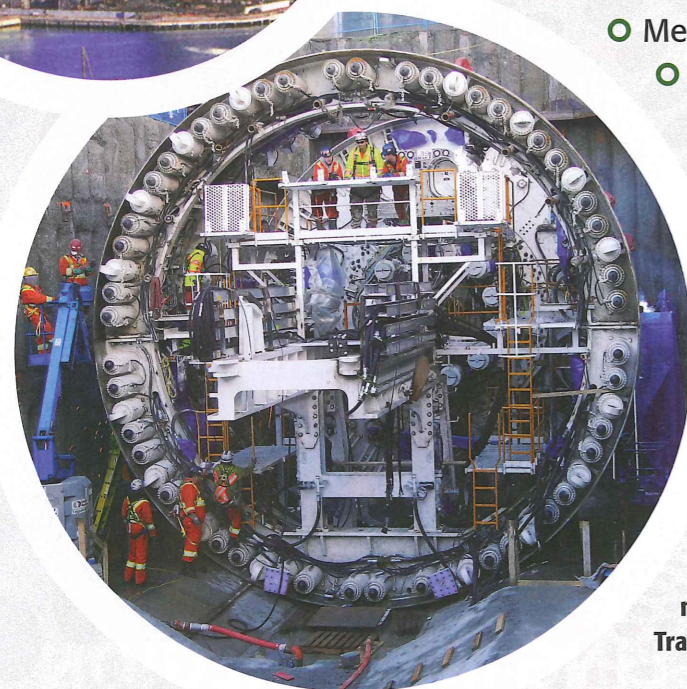
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UP IN LIGHTS

Raoul Lorphèvre and Jérôme Dehon of the Schreder Group discuss various lighting options and the effect different setups can have on issues such as energy consumption and maintenance

THE TUNNEL lighting environment has evolved significantly in recent years. Not only has LED technology entered the tunnel lighting world but the control of the different systems available in the tunnel has become an important element.

Today, despite these recent developments, the vast majority of tunnels are still lit entirely by high-pressure sodium or high-pressure sodium with fluorescent lamps (HID solutions). There are only a few cases of maintenance management or lamp lifetime optimisation. These HID solutions are not optimised and they consume a lot of energy; a total power consumption of more than 100kW for a 300m long tunnel.

This article will illustrate how tunnel lighting can be more efficient, using control systems, better lamp lifetime management and LED lighting.

MAINTENANCE MANAGEMENT AND CONTROL

It is possible to improve tunnel lighting design – whether HID or LED – to increase efficiency. There are five major areas where savings can be made: Develop a precise management of the lighting stages; raise the number of lighting stages; adjust the levels according to traffic speed; integrate control systems; the use of LEDs.

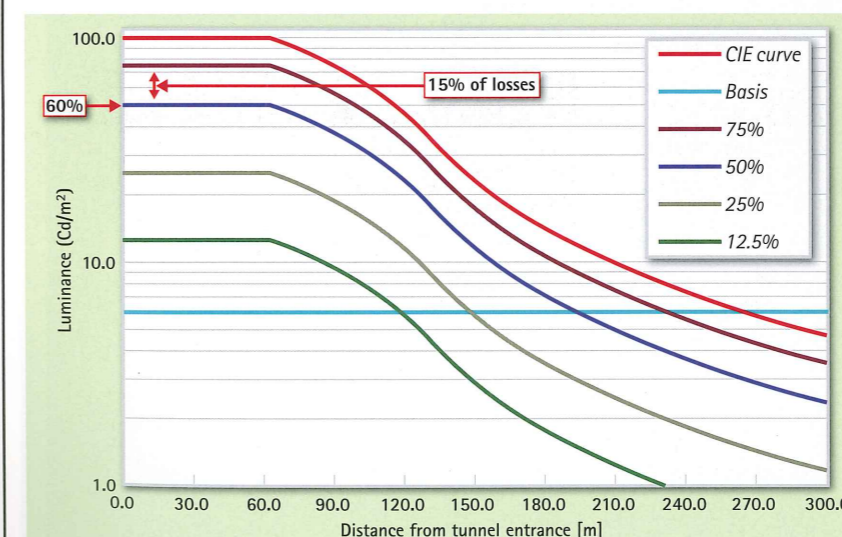
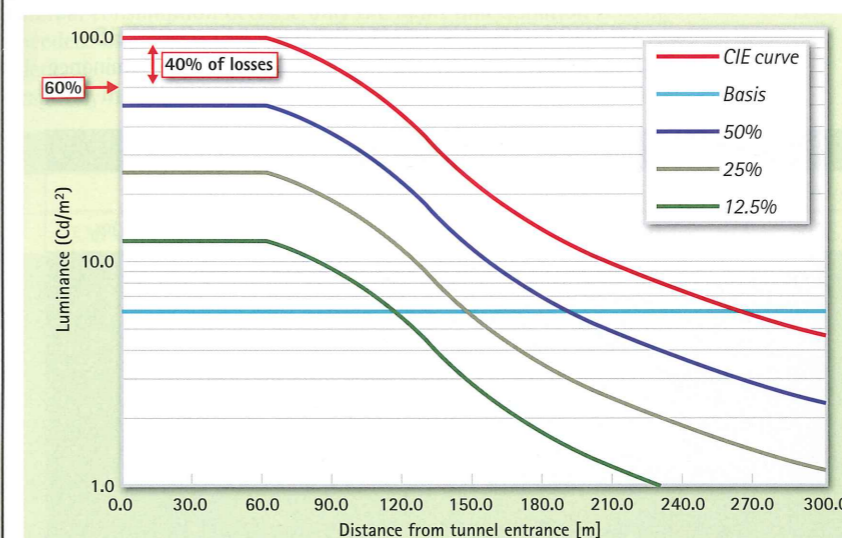
The tools to improve the efficiency of a tunnel lighting design must be defined before elaborating the first tunnel lighting design.

In complex tunnel environments, we have to consider the lighting control system as part of the complete tunnel control network, including ventilation, evacuation, traffic signalisation and security measures. Lighting manufacturers use industrial Ethernet-based protocols to control the lighting network. These are easy to integrate into the tunnel management system.

LIGHTING STAGES MANAGEMENT

In most tunnels, four different lighting stages are used in the entrance zone. Sometimes, mainly in northwest Europe, the highest lighting level only represents five per cent of the total operating time over a year.

In Table 1, the authors propose three alternatives for managing the different



Raoul Lorphèvre

Raoul is applications project manager at lighting provider, Schreder. He is responsible for energy efficient developments

Jérôme Dehon

Jérôme is a project manager at R-Tech, part of the Schreder Group that is responsible for research and development

lighting stages. In this table, the authors group luminaires within the same circuit (C1, C2...). The lighting stage "Simple" is the usual lighting stage management. In this type of management, the same luminaire is switched on in each lighting stage. Therefore the light source of the luminaires in circuit 1 (C1) will reach the end of its life before other light sources.

Another lighting stage management (Dimming) can be implemented with a simple control system using not only ON/OFF but also 50 per cent dimming to optimise the replacement of the light sources and installation costs.

The third alternative is the optimum solution because the management system can choose several groups of luminaires to light the same lighting stage. This way, for HID solutions, we extend the period between the lamp replacement from three years to eight or even 10 years. Consequently, maintenance costs are significantly

Previous page: Figures 1a and 1b, Diagrams showing the reduction in losses by adding extra stages

reduced. The maintenance lifetime of an HID solution can thus reach the maintenance lifetime of the LED solution. These three alternatives for managing the different lighting stages are not the only ones, other solutions do exist.

CLOSER TO THE CIE 88 CURVE

A tunnel is always over-lit in the entrance zone. With a better use of the CIE 88: 2004 curve, taking into consideration the lighting levels outside, the losses due to this excess lighting can be reduced. These savings can reach up to 20 per cent by increasing, for example, the number of lighting stages from four to eight. In a tunnel with four lighting stages, if the luminance in the access zone increases to 60 per cent of the L20 [Figure 1a], the management system will switch on the 100 per cent lighting stage. In this case, the power is 40 per cent higher than needed. If we add, for example, a 75 per cent lighting stage [Figure 1b], the losses will be reduced (15 per cent instead of 40 per cent).

With a 100 per cent LED installation in the entrance zone, the lighting could be permanently closer to the CIE curve 88.

ADJUSTING THE LEVELS TO TRAFFIC SPEED

Traffic speed is a critical element to determine the luminance level needed at the tunnel entrance. The speed criterion

should be taken into account in the tunnel lighting design to generate the first energy savings. In the case of an urban tunnel, by measuring the speed of traffic at rush hour, we can further adapt the levels at the entrance of the tunnel. Energy savings of 5 to 10 per cent can be achieved this way.

CONTROL SYSTEMS

The commissioning and maintenance in tunnels is a very important issue and should be as simple and as fast as possible. The maintenance costs have an important impact on the total cost of the system. Having a flexible control system makes it possible to easily integrate extra features like adapting the lighting according to traffic density, pollution environment adjustment, dynamic lighting evacuation systems and more. Monitoring and reporting the energy consumption and failures of luminaires, meters etc, provides managers with additional network information and visibility.

Another important element in determining an efficient tunnel lighting design is the operating time of each lighting stage. In road lighting, it is easy to calculate for example, the annual consumption because only the night time variation is needed. In a tunnel, the operating time of each lighting stage depends on the weather conditions. The average operating time can only be measured over a one year period.

10

The percentage energy savings that can feasibly be made with lighting level adjustment made based on traffic speed

LED TUNNEL LIGHTING

LEDs entered the tunnel lighting field a few years ago. In tunnel lighting solutions, we distinguish the entrance zone and the interior zone. While in the past tunnels were lit with HID luminaires for the entrance and HID or fluorescent fixtures for the interior zone, now we have moved towards HID or LED solutions for the entrance and almost completely to LED technology for the interior zone.

The requirements for the entrance are very different from those for the interior zone. The entrance requires 150 - 350cd/m², depending on the country, type of tunnel, orientation, speed, etc. With a HID solution, sources of up to 400W were needed for the entrance zone. Nowadays, the luminous flux of LEDs can compete with these high power HID sources. However, the ease of adaptation of the LED photometry to the tunnel's geometry ensures that

Table 1. Different lighting stages management. *c1/250w with bi-power ballast

	Mgmt ->	Simple				Dimming		
	Power	12.50%	25%	50%	100%	12.50%	25%	50%
1	HPS 400W	C1	C1	C1	C1	c1/250w*	C1	C1
2	HPS 400W				C2			
3	HPS 400W			C3	C3			C3
4	HPS 400W				C2			
5	HPS 400W		C4	C4	C4	c1/250w*	C1	C1
6	HPS 400W				C2			
7	HPS 400W			C3	C3			C3
8	HPS 400W				C2			
9	HPS 400W	C1	C1	C1	C1	c1/250w*	C1	C1
10	HPS 400W				C2			
11	HPS 400W			C3	C3			C3
12	HPS 400W				C2			
13	HPS 400W		C4	C4	C4	C1/250W*	C1	C1
14	HPS 400W				C2			
15	HPS 400W			C3	C3			C3
16	HPS 400W				C2			
17	HPS 400W	C1	C1	C1	C1	c1/250w*	C1	C1
18	HPS 400W				C2			
19	HPS 400W			C3	C3			C3
20	HPS 400W				C2			
21	HPS 400W		C4	C4	C4	c1/250w*	C1	C1

Source: Authors

	Choice of several groups						
	100%	12.50%	12.50%	25%	50%	50%	100%
C1	C1			C1	C1	C1	C1
C2					C2		C2
C3						C3	C3
C4							C4
C1			C5	C5	C5	C5	C5
C2					C2		C2
C3						C3	C3
C4							C4
C1	C1			C1	C1	C1	C1
C2					C2		C2
C3						C3	C3
C4							C4
C1			C5	C5	C5	C5	C5
C2					C2		C2
C3						C3	C3
C4							C4
C1	C1			C1	C1	C1	C1
C2					C2		C2
C3						C3	C3
C4							C4
C1			C5	C5	C5	C5	C5

Table 2. Results of the comparison between the different solutions

	100% HID installation	Hybrid installation	100% LED installation
Energy savings per year compared to HID installation	n/a	- 15 to - 20%	- 20 to -25%
Maintenance: lamp replacement	Every 3 years	Every 12 years	Every 12 years
Quantity of fixtures installed compared to HID installation (100% HPS)	n/a	5 - 10% more luminaires	10 - 15% more luminaires
Advantages		White light in interior zone	100% white light

Source: Authors

LED installations reach the same results with lower power consumption. The lighting in this zone is coupled to a L20 luminance meter. This luminance meter is situated outside the tunnel and has a variable output depending on the luminance outside.

For the interior zone, we only need two lighting stages: day and night. In this zone it is easy to move completely towards an LED solution because the requirements are much lower than the entrance zone, only 1 - 10cd/m².

The long lifetime of an LED installation is another advantage. Without any management, we can consider 12 years with no replacement.

COMPARATIVE STUDY

For the purpose of this analysis, we have compared 3 types of installation: 100 per cent HID; hybrid (a combining of LED and HID); 100 per cent LED.

For each installation, two types of tunnel were analysed: luminance threshold (Lth) of 150cd/m² for a length of 220m; and luminance threshold (Lth) of 350cd/m² for a length of 350m.

The chosen tunnel is just long enough to ensure that we reach the end of the entrance zone. We take this hypothesis because the interior zone is repeated along the tunnel. Four daytime lighting stages were taken into consideration: 100 per cent, 50 per cent, 25 per cent, 12.5 per cent; and one nighttime level: 33 per cent of the basic daytime level.

For the 100 per cent HID installation, the luminaires are equipped with high-pressure sodium (HPS) and bi-power ballasts. The interior zone is lit by HPS or fluorescent lamps.

For the Hybrid installation, the interior zone and the first two lighting stages are lit by LEDs. The remaining lighting stages are with luminaires fitted with HPS lamps.

The LED luminaires can be dimmed to switch between interior and lighting stages. And for the 100 per cent LED installation, all fixtures are equipped with LEDs and can be dimmed.

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Yearly power consumption and maintenance

The annual consumption is calculated by counting the power of each system during their operating time throughout the year. The hybrid solution uses between 15 and 20 per cent less energy than the HID solution. The LED solution uses between 25 and 30 per cent less energy compared to the HID solution.

We can decompose the annual consumption between the entrance and the interior zone. For the entrance zone, a 100 per cent LED solution can generate savings of up to 25 per cent in comparison with an HID solution. For the interior zone, more generous savings of to 60 per cent can be achieved.

The HID solution requires maintenance every three years to replace some of the lamps (interior zone and first stage lamps). For the hybrid and the 100 per cent LED solution, a lamp replacement is only required after 12 years (HPS sources have a shorter lifetime than LEDs). In an example for the hybrid solution, in a setup in Liège, Belgium, the operating time of the lighting stages are measured as:

- 100 per cent ≈ 100h/y
- 50 per cent ≈ 350h/y
- 25 per cent ≈ 1200h/y
- 12.5 per cent ≈ 3500h/y

LED luminaires are used for the interior zone and for the lighting stages of 12.5 per cent and 25 per cent while the HID luminaire will only be switched on for 450 hours/year. If you expect 16,000 hours for HPS lifetime, you can reach 35 years between each light source replacements.

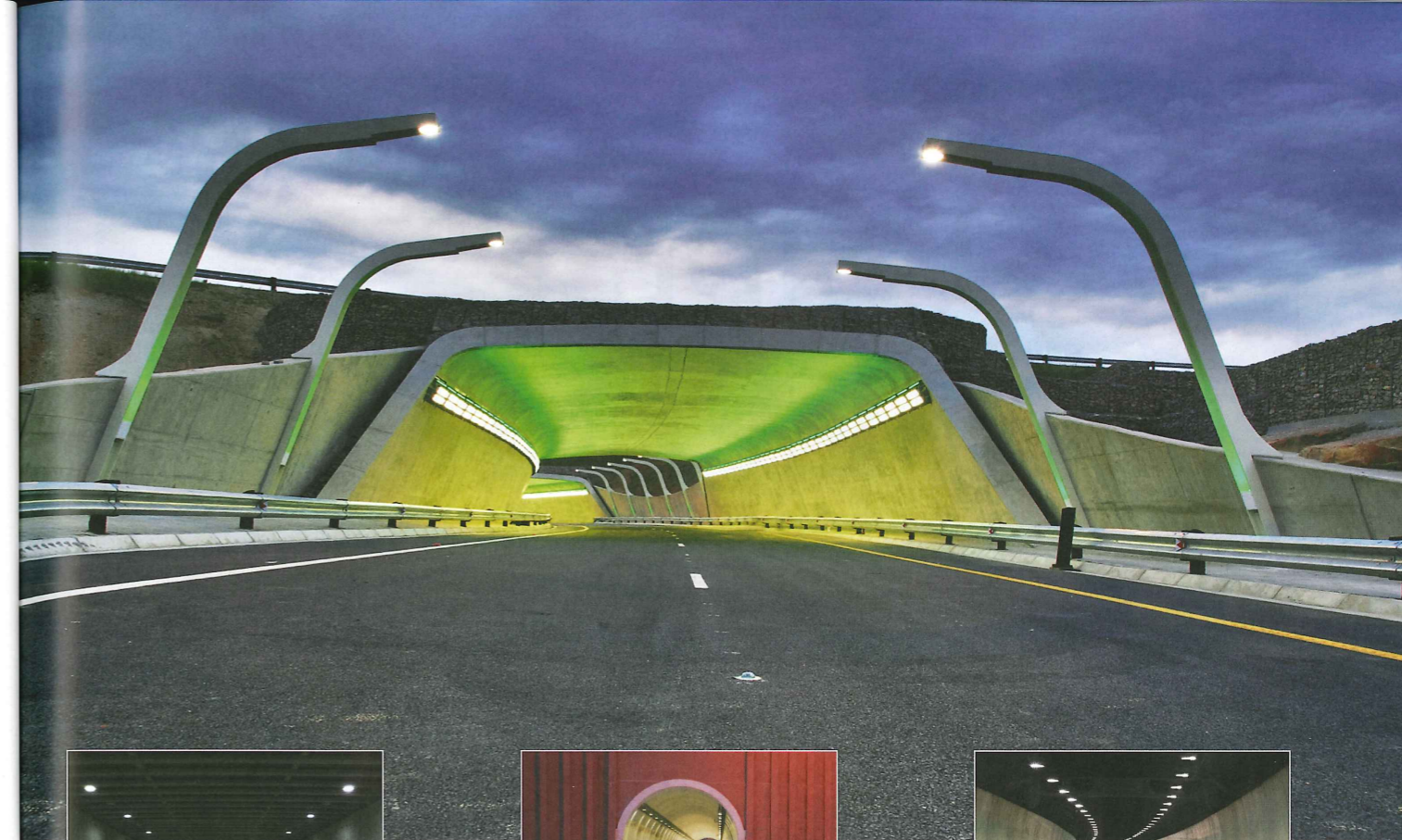
Fixture quantity

The 100 per cent HID solution (with only HPS) remains the most interesting in terms of minimum quantity of fixtures to install. The hybrid solution requires 10 per cent more fixtures and has been considered as a compromise between investment cost and savings. The LED solution requires up to 15 per cent more fixtures but offers a real alternative to HID solution.

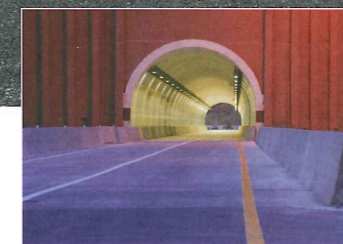
CONCLUSIONS

Even more than in road lighting, lighting management is necessary in tunnel lighting. However, this may only apply to new installations and must be implemented at the start of the project. Simple lighting management makes it possible to obtain interesting savings, even with HID. However, to carry out these studies, the tunnel lighting designer needs data. We strongly encourage tunnels managers to collect data.

To obtain efficient solutions, LED luminaires combined with dimming options are necessary. The improvements in LEDs and drivers means that they now offer a high lumen package to cover all the tunnel applications needs. Moreover, the white light provided by an LED solution (due to a much higher CRI than HPS lamps) offers better visibility when driving and improves the overall feeling of safety in tunnel conditions



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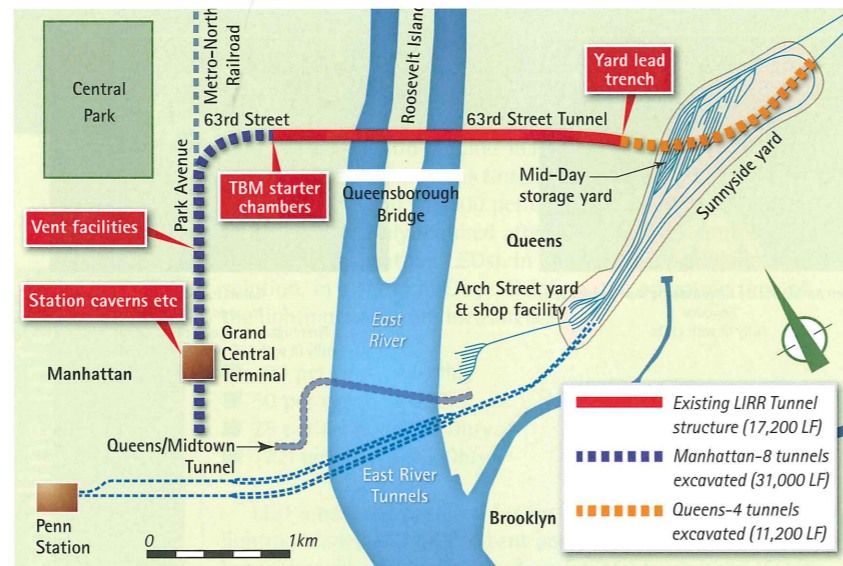
At February's joint BTS/Minsouth meeting, **Andy Thompson** of Hatch Mott MacDonald delivered a presentation on the use of explosives for the construction of New York's East Side Access. **Andrew Hindmarch** of Mott MacDonald gives this report from the meeting

THE ESA project in total is worth about USD 9.3bn and is the first expansion of the New York railroad in over 100 years bringing in the Long Island Rail from Queens into a new terminal beneath the existing Grand Central Terminal.

The project includes 10.5 miles (17km) of tunnelling with two station caverns and a general overview of the project was presented at the BTS by Andy Thompson in January 2011.

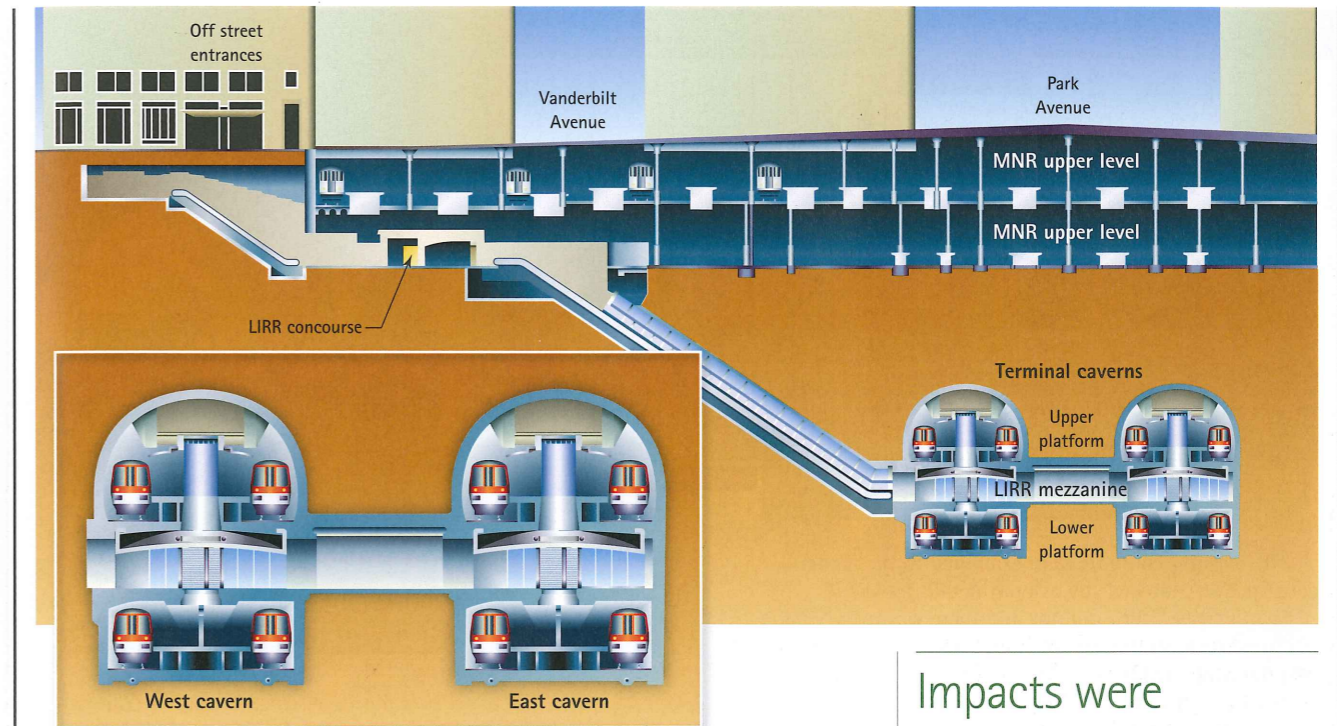
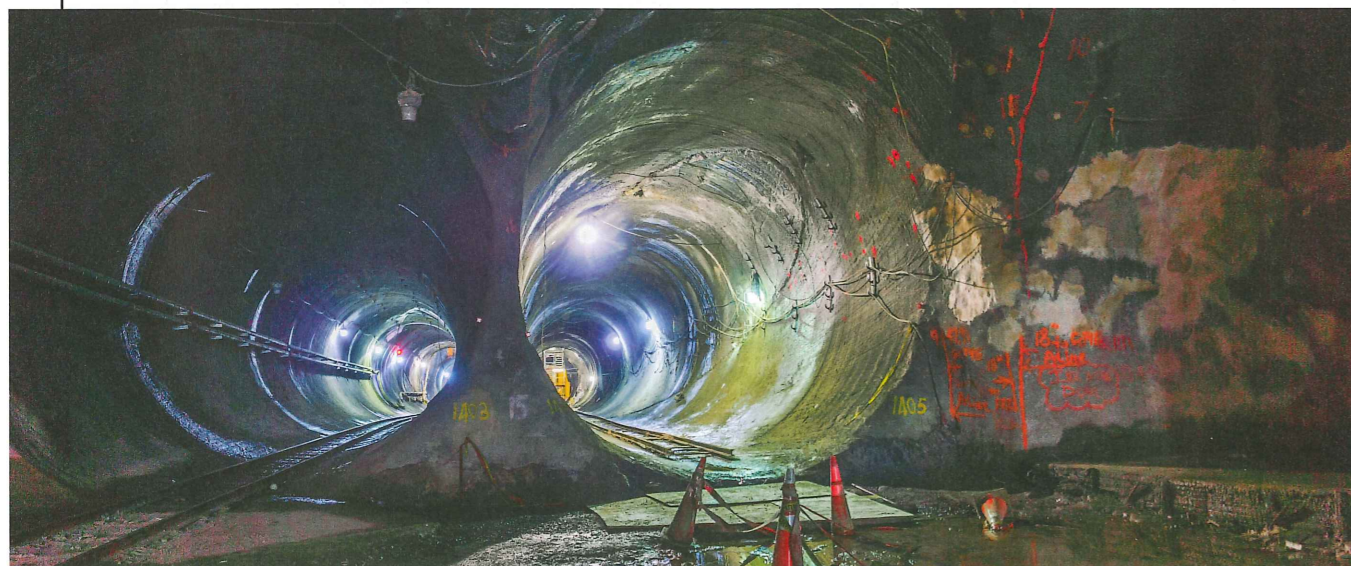
All blasting in New York is covered by the Fire Department (FDNY) and the regulations surrounding their use are governed by several factors including the terrorist attacks in 1993 on the World Trade Center. Every stick is individually registered and contains a trace element such that if any is found elsewhere then it can be traced back to New York.

The control of ground and structural movement due to vibrations when blasting is obviously a key factor in the regulations. The target was to try



Above: Figure 1, General overview with blasting locations

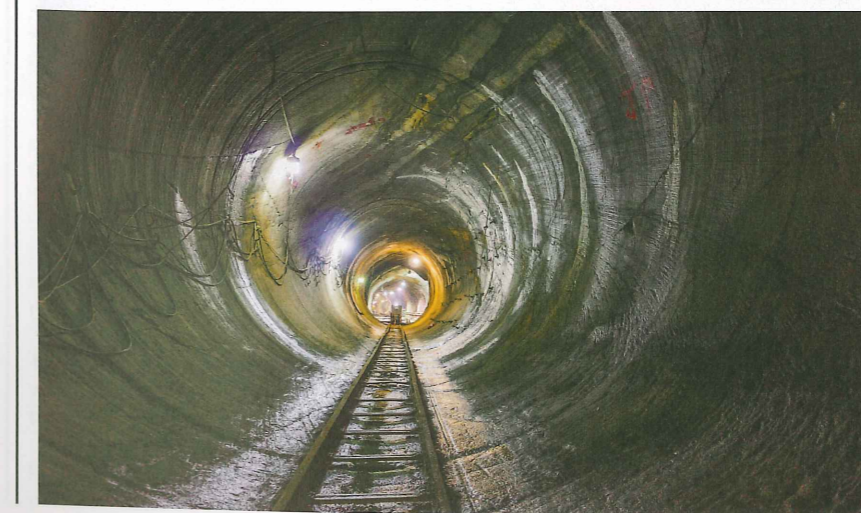
and keep within limits set by the US Bureau of Surface Mines. Figure 1 shows the areas where blasting has occurred. The East River separates the soft glacial till from the Manhattan schist. Figure 2 shows the station being built under the Grand



Central Terminal with all materials, except for concrete, being brought in by train. The terminal itself is the sixth most visited building in the world with 750,000 people passing through each day. 250,000 are commuters with the other half million visiting to eat and shop. Fortunately most of the blasting was under the non-historically important train shed. To complicate matters though there are also several utility tunnels under the station.

To avoid excessive dust on the surface, water cannons are used underground to act as water curtains to remove most particles after blasting through the ventilation tunnels. Whilst vibration controls and environmental management are standard features, the focus on quality control of blasting operations is unique to New York. Licenses are not granted to anyone who is not a contractor; so for the work to be assured, the blasting is checked and re-checked by different qualified staff. The main goal was to ensure no disruption of train services.

The vibration controls were self-controlled so for the columns under the station these were kept at 50mm/sec and 12.5mm/sec for historical structures with no blasting allowed

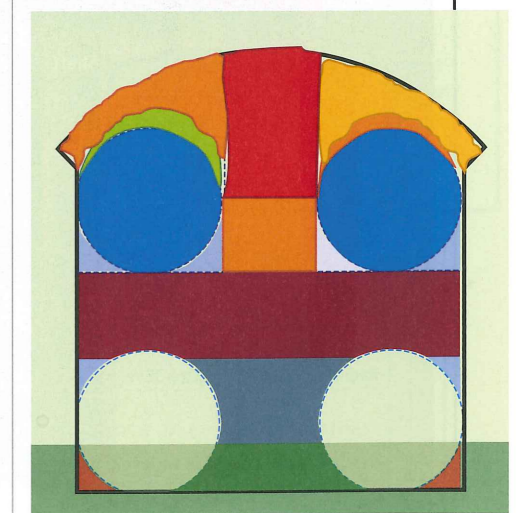


Impacts were assessed using micro strains, with review at 50, and alert at 100


within approximately 4m of an existing column footing. 25mm/sec was used for existing steam pipes, many of which had expansion joints at, or close to, their operational limit. Structural impacts were assessed using microstrains with a review at 50 microstrains and an alert at 100 microstrains. These were converted to stresses and then checked against the allowed overstress in columns. In reality the train movements were found to impart a higher microstrain than the blasting operations albeit with a different frequency.

Above: Figure 2, Station construction under Grand Central Terminal

Below, right: Figure 3, Sequential excavation pattern through cavern showing initial TBM drives



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28-31 August 2014
Istanbul, Turkey

The number of newly-excavated tunnels in Turkey is among the highest in the world, and in Istanbul, a great number of infrastructure tunnels are planned to be excavated soon, worth more than USD 10bn. Demos Faurcilik, in association with the Turkish Tunneling Society, is organising the third short course on tunnelling in Istanbul, along with a tunnel technology fair.
www.demosfuar.com.tr

Fire Protection and Safety in Tunnels 2014

10-11 September 2014
Bergen, Norway
Fire Protection and Safety in Tunnels returns after last year's event in Copenhagen, which set new standards for case study, industry driven presentations and networking opportunities. Norway is hosting the sixth annual FPST event, a country with an impressive network of more than 900 road tunnels alone.
www.arena-international.com/fpst

15th Australasian Tunnelling Conference

17-19 September 2014
Sydney, Australia
The Australasian Tunnelling Society's triennial conference, and registration is scheduled to open online this month.
www.atstunnellingconference2014.com

BTS Conference 2014

23-24 September 2014
London, United Kingdom
The BTS Conference has risen to become the UK's largest tunnelling and excavation event, and is the only show supported by the BTS.
www.btsconference.com/content

InnoTrans

23-26 September 2014
Berlin, Germany
An international platform for buyers and sellers of passenger and freight transport technology, InnoTrans focuses on railway technology. The Tunnel Construction segment will be accompanied by the International Tunnel Forum, which

will feature a series of international discussions
www.innotrans.de

ExpoTunnel
23-25 October 2014
Bologna, Italy

Following the success of the inaugural exhibit in 2013, with 105 exhibitors, 20 per cent from outside of Italy, and 5,400 visitors, plans are set for the second edition of ExpoTunnel. The event is dedicated to the world of tunnelling, drilling, mining, underground construction and research, and is facilitated in collaboration with the Italian Tunnelling Society (SIG).
www.expotunnel.it

TAC 2014 Annual Conference

26-28 October 2014
Vancouver, British Columbia
The Tunnelling Association of Canada's Vancouver TAC 2014: Tunnelling in a Resource Driven World will include plenary presentations, technical sessions, and a trade exhibition all designed to highlight advancements in tunnelling research and practice from around the globe. This event will include TAC's Annual General Meeting and Awards
www.tac2014.ca

2015

Shotcrete conference and exhibition

29-30 January 2015
Tyrol, Austria
Wolfgang Kusterle and his team welcome you to the Conference and Exhibition Shotcrete 2015 at the Alpbach Conference Centre. Knowledge and experience do not help, if they remain hidden. This platform has gathered shotcrete specialists for 25 years, in a surrounding field where the exchange easily takes place.
www.spritzbeton-tagung.com

ISRM Congress 2015

10-13 May 2015
Montreal, Canada
Held in conjunction with the CIM Convention for 2015, the International Symposium on Rock Mechanics holds its international conference every four years. A one day symposium on "Shale and

Rock Mechanics" is planned.
www.ISRM2015.com

World Tunnel Congress 2015
22-28 May 2015

Dubrovnik, Croatia
WTC 2015 heads to the Dalmatian Coast as the event returns to Europe. Further details to be confirmed.
www.wtc15.com

RETC

7-10 June 2015
New Orleans, Louisiana
The Underground Construction Association's biennial conferece.
www.smenet.org

25th World Road Congress
2-6 November 2015

Seoul, South Korea
The World Road Congress has been held every four years for more than 100 years. It tours the member nations of PIARC.
www.aiprcseoul2015.org

British Tunnelling Society

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

Crossrail Western Tunnels, urban tunnelling through the capital

18 September 2014
This presentation will cover the whole development of the Crossrail Western Tunnels, from design, through procurement and to construction and successful completion. Andy Alder of CH2M Hill, Adrian StJohn of BFK and Stephan Fleischman, also BFK, will speak. This presentation will be given as part of the BTS Conference 2014.

"What could possibly go wrong with a site investigation in chalk?"

16 October 2014
A review of case histories and the importance of site investigations and particularly the analysis of the results. To include case histories of good and bad practice. The speaker is Rory Mortimer, Brighton University.

If you have a topic or project you feel would be suitable for a BTS presentation, please contact greg.james@ice.co.uk or daterry@bssujv.com

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