

SEPTEMBER 2010

tunnels



& tunneling
NORTH AMERICA



Special report: East Coast Part II

T&TNA looks at metro work in New York and Toronto

Insight: San Francisco

T&TNA looks at plans for the city's Central Subway and visits the mix-use tunnel project at Cal Park

WWW.TUNNELSONLINE.INFO

Carving New York's No. 7 Line

A look at tunnelling works on the No. 7 Line extension in New York City





FINAL BREAKTHROUGH IN NEW YORK.

On July 15, 2010 the TBM team of S3II Tunnel Constructors broke through the target shaft wall 12 meters beneath the New York Port Authority Bus Terminal using the Herrenknecht Double Shield S-467. "On time and on budget", emphasized New York's Mayor Michael Bloomberg. The S-467 sister machine had reached its target on the parallel route already on June 11, 2010. The two tunnel boring machines (diameters 6,810mm), named Georgina (S-467) and Emma (S-468) started their mission in Manhattan's underground through hard rock in June and July 2009 respectively. The tunnel specialists of the Joint Venture companies J.F. Shea Construction Inc., Skanska USA Civil and Schiavone Construction Co. have been very successful with the Double Shield technology "made by Herrenknecht", used for the first time in a US-American project.

After final completion, the extension of subway line 7 will lead through the new tunnels from Times Square to the banks of the Hudson River. The new connection will mark the start of the urban further development of the Hudson Yards, a quarter right at the heart of the cosmopolitan city which has until now been less developed.

NEW YORK | USA

PROJECT DATA



S-467, S-468
 2x Double Shield TBM
 Diameter: 6,810mm
 Cutterhead power: 2,100kW
 Tunnel lengths: 1,422m, 1,410m
 Geology: slate, granite, serpentinite

CONTRACTOR

J.F. Shea
 Construction Inc.,
 Skanska USA Civil,
 Schiavone
 Construction Co.





comment

Get out the vote

You can't deny Benjamin Franklin his oft repeated adage of "in this world nothing can be said to be certain, except death and taxes." But it seems taxes—normally an election year darling—while still certain, are taking a back seat.

The Ottawa mayoral election is locked in a heated debate over a CAN 2.1bn (USD bn) Light Rail plan with a 3.2km downtown tunnel estimated to cost CAN 735M (USD bn). A poll by local newspaper the Ottawa Citizen says public transport is the most important policy issue among city voters, ahead of taxes.

Ottawa is not alone. Many of the candidates vying to be Calgary's next mayor support the proposed traffic Airport Tunnel. One who's quite vocally opposed, Bob Hawkesworth, says "they need to come to grips with reality" because the city does not have the cash to build the tunnel. The estimated price tag on the 700m tunnel varies by candidate and government agency.

In Toronto, mayoral candidates see the Toronto Transit Commission (TTC)'s Transit City as an integral election platform. George Smitherman outlines his Integrated Plan for Toronto with a two-phase expansion of that calls for tunnelling to be underway for the Eglinton light rail transit to integrate with the new Air Rail link station by 2015. Candidate Rocco Rossi has promised to fund rapid transit with CAN 4.5bn (USD 4.3bn) over 10 years, which would include "continuous tunnelling of 2km and one new station opened per year on average." Sarah Thomson says she's been working with early TTC maps and density plans and estimates the city needs to expand approximately 58km of subway system, some above ground and some underground.

Elections for both Toronto and Ottawa will be held Monday, October 25. Calgary will go to the polls on Monday, October 18.

Meanwhile, the US is gearing up for the Tuesday, November 2nd midterm elections. Though cable news would have you to believe most races revolve around tea and mosques, high-speed rail is making its mark among the usual campaign issues.

With forecasts for democrats to lose congressional and gubernatorial seats, President Obama attempted to throw a life ring to the party this Labor Day. He announced a proposal for a new transportation bill to update roads and build rail, with a USD 50bn cash injection for the first year. The bill must first pass congress—a congress with only a few weeks left until its members return home to campaign.

2010 may be the year to take the vote underground.

Nicole Robinson

contacts

HEAD OFFICE: Word Market Intelligence
John Carpenter House, 7 Carmelite Street, London EC4Y 0BS, UK

WEB ADDRESS: www.tunnelsonline.info

EMAIL: editor@tunnelsonline.info

TEL: +44 20 7336 5256

FAX: +44 20 7936 6813

EDITORIAL

EDITOR: Jon Young
Tel: +44 20 7336 5256 Email: jyoung@tunnelsonline.info

TECHNICAL EDITOR: Maurice Jones
Tel: +44 01296 397 353 Email: mjones@tunnelsonline.info

NEWS EDITOR: Kris Mole
Tel: +44 20 7936 5257 Email: kmole@tunnelsonline.info

FEATURES EDITOR: Nicole Robinson
Tel: +44 20 7936 5258 Email: nrobinson@tunnelsonline.info

PRODUCTION & DESIGN

DESIGNER: Natalie Kyne

TECHNICAL ILLUSTRATOR: Nick Stenning

PRODUCTION CONTROLLER: Loraine Lee

ADVERTISING

HEAD OF SALES: Shelly Palmer
Tel: +44 20 7936 6848 Email: spalmer@tunnelsonline.info

NORTH AMERICAN SALES: Clive Bullard
Tel: +1 845 231 0846 Email: cbullard@tunnelsonline.info

EUROPEAN SALES MANAGER: Randolph Krings
Tel: +49 611 5324 416 Email: t&t@mcmedia.de

contents

NEWS

5 NORTH AMERICAN ROUND UP

SPECIAL REPORT: EAST COAST PART II

9 WORKING ON THE WEST SIDE

15 RUSHING AHEAD IN TORONTO

INSIGHT: SAN FRANCISCO

21 STRAIGHT DOWN THE MIDDLE

25 NEW DOUBLE LIFE FOR MARIN COUNTY LINK



On the cover

New York, home to North America's largest subway system, is a hotbed of tunnelling activity. This summer saw breakthroughs on the extension of the No. 7 line, one of the many projects happening in and around Manhattan. The extension includes roughly 2km long twin tunnels and a new station.



Your goal is our goal

Aker Wirth GmbH

Aker Wirth is a leading supplier of equipment to the oil and gas drilling industry, and of products for mining and civil construction.

For well over a century Aker Wirth has delivered innovation in the efficient development of natural resources and infrastructure, promoting commercial and social growth.

News in brief

Managers escape jail time

Two former managers for Aggregate Industries NE convicted of supplying substandard concrete to Boston's Big Dig highway project have avoided jail terms. The pair was convicted of 135 felony counts including conspiracy to defraud the government with respect to claims.

Curved micro completion

Northeast Remsco Construction successfully completed a planned, curved microtunnel in Hartford, Connecticut, for the Metropolitan District Commission. Designed by AECOM, it's one of the first curved microtunnels constructed in the US. A Herrenknecht AVND 1800AB MTBM was used for the drive, equipped with a SLS Microtunnelling LT guidance system supplied by VMT GmbH.

Xcel at fault

The U.S. Chemical Safety Board (CSB) determined Xcel Energy to blame for the deaths of five industrial painting contractors in a 2007 Colorado hydroelectric plant tunnel accident. CSB highlighted Xcel and contractor RPI Coating's lack of planning and training for hazardous work, and Xcel's decision to use RPI, which has the lowest possible safety rating among competing contractors.

THE contract awarded

A joint venture of Skanska, Schiavone and Shea has been awarded a USD 258M design/build contract for a new rail tunnel in New York by client New Jersey Transit. The contract relates to the twin 1,600m-long Palisades Tunnels, which are part of the Trans-Hudson Express project.

Work begins on Caldecott fourth bore

CALIFORNIA

Boring began last month on the Caldecott Tunnel's fourth bore in California. The job is expected to take three years to complete. The tunnel is being bored by roadheader.

The fourth bore project relies on almost USD 198M in federal stimulus dollars, making it

America's second largest investment of Recovery Act highway funds.

When completed in 2013, the new 1.03km tunnel will have 3.65m lanes, shoulders and emergency walkways.

The Caldecott Tunnel currently has three bores, which give drivers a total of six lanes. The USD 420M total project will create a two-lane

tunnel bore north of the existing three Caldecott tunnels.

The roadheader will tunnel west toward Oakland from Orinda to be met in the months ahead by two smaller roadheaders boring eastward. Work crews will advance from both sides of the new tunnel, excavating and stabilizing small segments as they go, moving one to two metres a day.

Toronto tunnel gets 14 expressions of interest

ONTARIO

The Toronto Port Authority (TPA) has secured 14 expressions of interest for its pedestrian tunnel that will connect the mainland to Billy Bishop Toronto City Airport under Toronto harbour.

The total cost of design,

building, financing and maintaining the tunnel will be borne by passengers through a CAD 20 (USD 19) airport improvement fee, once the tunnel is complete.

TPA has issued requests for qualifications for the project. Based on the responses it has received, the authority expects to identify a shortlist of three joint

ventures to go on to the next stage of the competitive selection process.

TPA stated that it had not requested any government funding for this project and is not planning to seek public sector funds to assist in the construction and operation of the public-private partnership pedestrian tunnel.

Ontario approves environmental assessment

ONTARIO

The Canadian province of Ontario recently approved an environmental assessment on the multi-billion Ottawa light-rail tunnel (LRT) project.

The city's director of rail implementation, John Jensen, stated in a memo that the provincial environment ministry had approved LRT's environmental assessment, which examined the potential impact of a 12km light-rail transit line from Tunney's Pasture to Blair Station, including a 3km tunnel through downtown from LeBreton Flats to the

University of Ottawa.

The total cost of the project is CAD 2.1bn (USD 2bn), of which the provincial and federal government would contribute CAD1.2bn (\$1.16bn), while the city will have to raise at least CAD 900M (USD 872M).

The city is now obtaining engineering design bids for the rail line, tunnel and stations.

The Tunney's Pasture-Blair Road project is the first phase of a larger, CAD 5.6bn (USD 5.42bn) transit master plan that has been split into two parts to be completed over the next two decades.

The first phase, which is estimated to cost about CAD 3.7bn (USD 3.58bn), is itself divided into three parts—the CAD 2.1bn (USD 2bn) Tunney's-Blair line, which will be completed by 2018 and become operational in 2019; a second phase that includes extending a rail line from Tunney's Pasture to Baseline Station, subject to the availability of funds; and a third line from Bayview to South Keys that will replace the existing diesel O-Train with electric rail.

The latter two projects are estimated to cost about CAD 1bn (USD 969M) each.

News in brief

▼ New Irvington tunnel contract

The San Francisco Public Utilities Commission awarded the New Irvington Tunnel Project contract to the Southland Contracting/ Tutor Perini Corporation joint venture. Its bid of USD 226.6M was the lowest qualified for the new 3.5 mile tunnel, with an internal diameter of approximately 8.5 to 10.5 feet.

▼ Alaskan Way project sends out RFPs

The state of Washington has sent out requests for proposals to three teams vying to design and build the 2.7km deep-bore Alaskan Way Viaduct replacement tunnel. Teams will submit their proposals this autumn, with the bid to be awarded early next year. Tunnel boring construction is estimated at USD 350M.

▼ Calls for comment on tunnel inspection standards

The Federal Highway Administration (FHWA) has requested comment on a proposed rule to establish national uniform standards for federal tunnel inspections. Currently, FHWA provides tunnel inspection guidance, but existing regulations do not require tunnel owners to inspect tunnels. Inspection methods vary significantly among the roughly estimated 350 highway tunnels in the US. Referred to as National Tunnel Inspection Standards, the proposed new standards would be modeled after National Bridge Inspection Standards, which were first implemented in 1971.

▼ BC tunnel fire left to burn itself out

A fire inside the Adra Tunnel on the Kettle Valley Railway in British Columbia was left to burn itself out as it posed a

safety risk to fire crews.

Authorities decided against extinguishing the blaze over concern for smoke inhalation and the tunnel's structural instability. It had previously been condemned and closed to the public due to falling rock and flooding.

▼ Irvine-Corona Tunnels shelved

Officials have declared a tunnel connecting California's Orange and Riverside counties, beneath the Santa Ana Mountains, too expensive and have suspended the project. The proposed Irvine-Corona Expressway Tunnels for traffic and rail would be approximately 11.5 miles long and funded through toll collection.

▼ Hawaii looks into two new sewer tunnels

The city of Honolulu has identified two 3 mile sewage tunnel routes as potential replacements for the current system carrying wastewater from Kaneohe to a treatment plant in Kailua. One option would involve a 13ft wide concrete tunnel beneath the Oneawa Hills using a TBM. The other is a 36in pipe bored under the bottom of Kaneohe Bay. A report on costs and environmental effects for the lines will be published later this year.

▼ Water delays tunnelling on Lake Mead reservoir

Tunnelling for the third water intake at Lake Mead in Las Vegas has been delayed after workers hit a pocket of water. Over four days inflow from behind the face of the starter tunnel entered the area and the assembly chamber. The site has been mucked out and the project is working to re-establish the face of the starter tunnel. It's not certain if this will delay completion.

Tunnel is only option in Ottawa, says councillor

ONTARIO

Ottawa city council's transit committee chairman believes the city's light rail transit project could go back to square one if any major changes, such as removing the downtown tunnel, are now made. This comes after the provincial government of Ontario accepted the environmental assessment on Ottawa's CAD 2.1bn (USD 2bn) light rail plans.

Bay Councillor and Mayoral candidate Alex Cullen this week had a dig at anyone questioning the need for a tunnel, saying a significant change to the project would mean redoing the environmental assessment, plus more public consultation and background studies - something that took council four years to complete for its current project.

Cullen said in response to council candidates' questioning the potential cost of the tunnel, "for all intents and purposes, the tunnel debate is dead, because your other choice is to restart the whole process."

Mayoral candidate Jim Watson has publicly fretted about the CAD

735M (USD 713.9M) estimated cost of the tunnel, and councillor and mayoral candidate Clive Doucet has said the tunnel should be scrapped and a rail line run along Carling Avenue instead.

The environmental assessment looked at the potential impact of a 12km light rail transit line from Tunney's Pasture to Blair Station, including a 3.2km tunnel through the centre of the city.

Deputy city manager Nancy Schepers, who is in charge of transit, agreed with Cullen. Pulling out of the tunnel option would mean the city would have to "go back to the drawing board on its transit plan," she said.

Schepers added that, "looking at another option, such as surface light-rail, would require figuring out how the system would work with different traffic volumes. That's a lot of hard work."

Cullen said a procurement report will be completed next year. "The risk of any cost change does rest with the City of Ottawa, and obviously, city council will be looking very closely at the procurement process and its options in terms of controlling those costs," he said.

Obama proposes transport bill

WASHINGTON D.C.

US President Barack Obama on the Labor Day holiday proposed a six-year plan to revamp highways, rails and airport runways to create jobs and improve the US transportation network.

The bill, which will need to be passed by Congress, will include an initial USD 50bn investment for the first year. Speaking at labour rally in Milwaukee, President Obama said he would make sure the bill is fully funded.

"It will not add to the deficit over time—we're going to work with

Congress to see to that," he said.

The bill would rebuild 150,000 miles of roads and bridges, and build and maintain 4,000 miles of both high-speed and commuter rail lines.

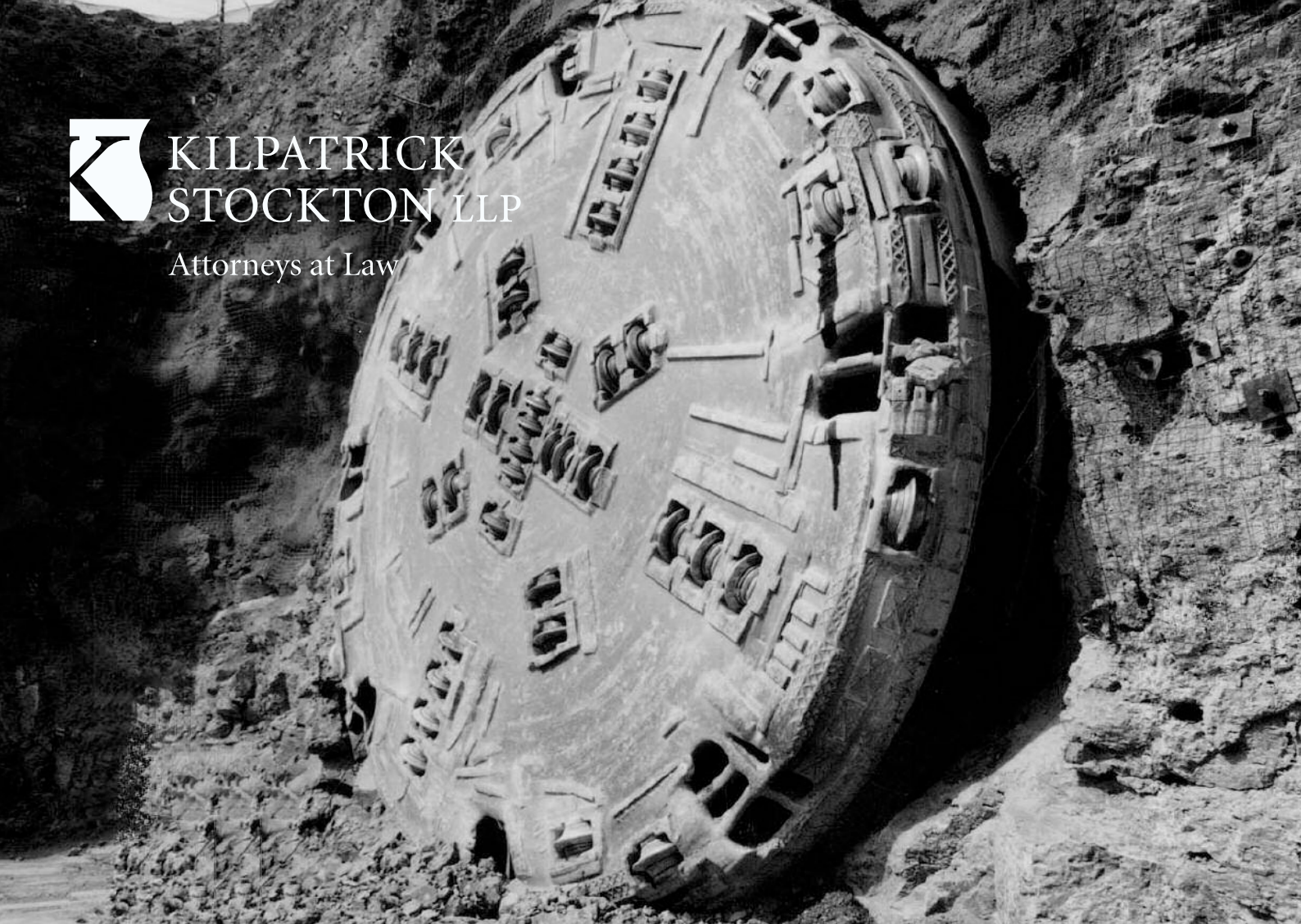
President Obama highlighted the need for high-speed rail, saying, "we're going to continue our strategy to build a national high-speed rail network that reduces congestion and travel times and reduces harmful emissions."

Despite eight straight months of private sector job growth, nearly one in five construction workers are unemployed in the US.



KILPATRICK
STOCKTON LLP

Attorneys at Law



Contract Negotiation • Dispute Avoidance and Resolution • Mediation • Arbitration • Litigation

DEEPLY RELEVANT

Kilpatrick Stockton cannot help you build a better tunnel —
but we can help you prove it.

Global Construction & Infrastructure Practice

Randall F. Hafer

rhafer@kilpatrickstockton.com

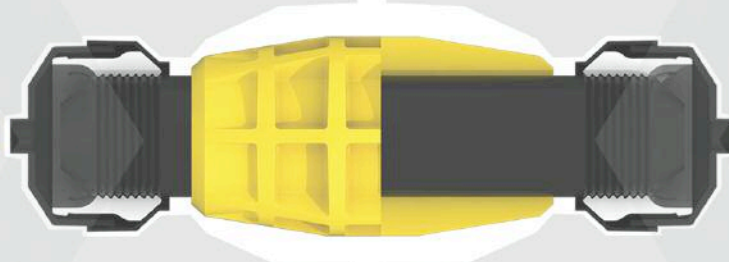
404 815 6289

www.kilpatrickstockton.com

ATLANTA AUGUSTA CHARLOTTE DUBAI NEW YORK RALEIGH STOCKHOLM WASHINGTON WINSTON-SALEM



The Dowellock System



Tunnel Section A

Tunnel Section B

BOSWORTH PLASTICS LTD and **TUNNELLING ACCESSORIES LTD** have formed a JV Company **TECHNICAL TUNNELLING COMPONENTS**, which brings together the expertise of two established companies, offering excellent service and experience to provide innovative solutions for your tunnelling needs.

- * **TTC** designs and manufactures in-house a wide range of plastic components for precast segment connection and grouting.
- * In-house design facilities allow us to modify any standard product, or design bespoke components to customer's individual requirements.
- * Products have been used on various projects around the world, especially our patented award winning Dowellock Alignment system.

For more information please visit: www.ttcltd.org or call + 44 (0) 1455 234401

Products designed and manufactured by Technical Tunnelling Components include;

- * Grout and lifting sockets
- * Non return valves
- * Segment handling/lifting devices
- * Spear bolt sockets
- * Spear Bolts
- * ME fixing sockets
- * Alignment Dowels
- * Bolt hole formers
- * Grummets

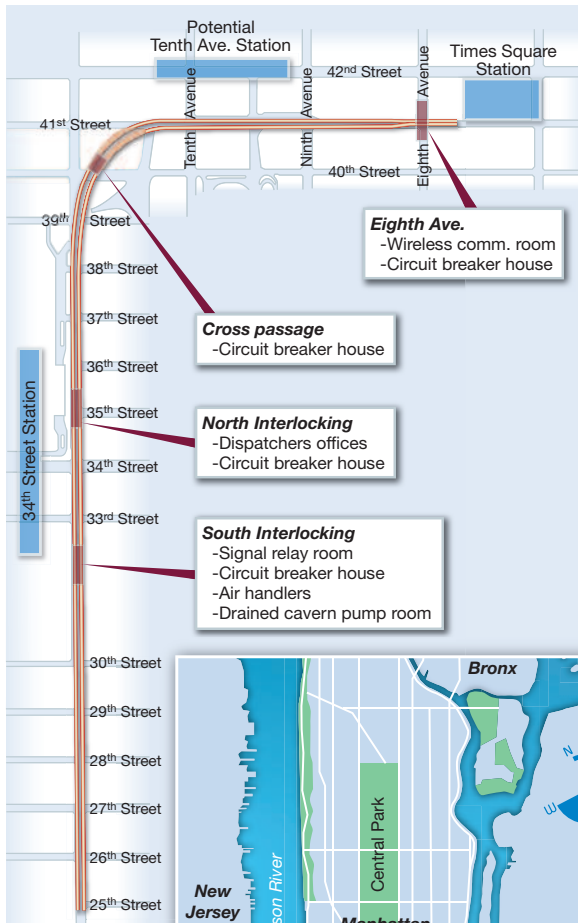


bosworthplasticslimited

TTC
TECHNICAL TUNNELLING COMPONENTS

TA Tunnelling Accessories

Working on the west side



Manhattan's largest undeveloped single piece of property, the Long Island Rail Road rail yard, makes its home on the far west side of Manhattan from 31st to 33rd Street. The surrounding neighbourhood is underused and underserved except for the recently expanded Jacob K. Javits Convention Center to which visitors have two choices for arrival by public transit; bus routes M34 and M42. The nearest subway line is three blocks away and parking garages in the area charge USD30-50 a day, but of course there are always taxis.

This lack of infrastructure was somewhat of a blessing when it came time to plan an extension to the No. 7 Line, which would service the convention centre. With not much existing above ground and not much below there was room to move, and to mine. But the same could not be said at the current terminus for No. 7 - Times Square Station. Here the underground space is already crowded with subway lines, Amtrak rail and tubes for the Lincoln Tunnel.

Designing an alignment to meet the current line and navigate the existing underground structures meant mixed face conditions of rock and soil near the start of the extension were unavoidable. The contractor, S3II Tunnel Constructors, a joint venture of Shea Construction, Skanska USA and Schiavone Construction, chose to freeze the ground before employing two double-shield, hard-rock TBMs to mine the twin tunnels. Their breakthrough this July sees a project that has seen smooth sailing six months ahead of schedule.

That's good news for everyone, particularly the City of New York, which floated bonds to fund the USD2.1bn project as part of an initiative to develop that area of western Manhattan, and rezoned the rail yard from manufacturing to residential and commercial use. Currently the No. 7 Line travels from Flushing, Queens to Times Square Station. The extension will bring the line further west and south with a new station at 34th Street and 11th Avenue for the Javits Center. The extension will provide mass transit access to hundreds of

This summer saw a major milestone for the No. 7 Line Extension project, with the final breakthrough of the two TBMs mining the twin subway tunnels. Nicole Robinson looks into the project and its progress

thousands of people who will eventually live and work there, explains Michael Horodniceanu, president of MTA Capital Construction.

"Providing mass transit access became imperative," he says of the development project. "The rezoning—that allows for higher density to be created there, and the possibility of a tax district will enable the city to pay back the bonds from the development."

A running start

In December 2007 a USD1.14bn contract to construct the 6,600ft (2,012m) tunnels and the 34th Street station cavern was awarded to S3II, which started work in February 2008. The original design extended the No. 7 Line from Times Square Station, under 41st Street, and then turning south, running under 11th Avenue, with tail tracks going down to 26th Street. Initially the extension called for the new terminal station at 11th Avenue and 34th Street, plus a station at 10th Avenue and 41st Street (figure 1). But the 10th Avenue Station was removed from the plan due to a lack of funding.



At 130ft (39.6m) below ground, the two new tunnels are relatively deep compared to other underground structures already there, says Peter Wahl, project manager for the No. 7 Line extension for Parsons Brinckerhoff. The deepest point of the new tunnels is at 26th Street where the TBMs were launched. Between that point and the new station at 34th Street there is a 0.5 per cent gradient, and within the station there is another 0.5 per cent gradient. Then it

increases to around 3.5 per cent continuously until the alignment meets the existing tail track of Times Square Station. Not only did that mean the alignment would fall into mixed face, but also that as the tunnels reach 41st Street, and turn right, the 650ft (198m) radius curve has a gradient increase as well.

To launch the TBMs, a 38ft (11.6m) access shaft was built to the side of 11th Avenue with secant piles to support soil

Above: Precast concrete segments built the lining as the TBMs bore the tunnels

overburden and with shotcrete and rock bolts for the remainder. The rock section of the shaft was excavated using drill and blast. A large gallery was driven across from east to west underneath 11th Avenue, with a 200ft (61m) starter tunnel running north and a 200ft tail tunnel running south for each tunnel. These were excavated using drill and blast.

Herrenknecht supplied two identical double-shield TBMs of 6.81m (22ft 4in.) diameter and 17-in. cutter discs: 36 front and gauge discs and four twin discs in the centre. These were shipped from Germany to a port in New Jersey and trucked to the job site. They required full assembly. Each TBM cutter head came in three pieces that were welded together at the surface and lowered down, says Jim Rosteck, director of engineering for S3II. Once the TBMs were moved up into the starter tunnels the contractor had spray-concreted a round launching area where the grippers were able to react against the walls and thrust off, he explains.

The first 300ft (91.4m) of the drive was through frozen ground. Working with subcontractor Layne Christensen about 280 freeze pipes were drilled from 11th Avenue. These consisted of a 3in. diameter

The future of the 10th Avenue Station

The proposed 10th Avenue Station had been scrapped from the original concept, but discussions of its potential resurfaced this summer. New York City mayor, Michael Bloomberg, is applying for USD3M of federal funding to pay for an engineering study looking at the feasibility of building the 10th Avenue Station in the future, after the project is finished.

"We already have some preliminary studies that show that it will be possible to build the station even after No. 7 Extension is completed in its present configuration," says Horodniceanu of the MTACC. "And the design that will be studied is really going to be based on the conceptual work that was done."

He adds that the MTACC believes the study will show that there is an ability to build at a later stage and that opportunities will exist in the future to expand. Looking across the federal, state and city levels, the finances are not there to support a new station, but that won't always be the case, he explains. "What we're doing is we're creating the infrastructure to retain the opportunity to build a station in the future."

All agencies involved in the extension and the Hudson Yards Development project and the 7 Line extension have been sure to state they cannot pay to build the station. But Horodniceanu optimistically points out, "the important part is, we will have the ability to build it when the need will be there and the money will be there."

outer pipe capped on the bottom and second pipe running down the centre. Freeze plants using an ammonia refrigerant circulated calcium chloride solution through the pipes to remove the heat from the ground.

S3II launched the first TBM in June of 2009, deciding to stagger the two as they bore through the frozen ground. The second TBM started one month later. Rosteck says the advance rates were a little bit slower through the frozen ground compared to the rest of the tunnel. But, he notes, "Whenever you're starting up a TBM you have your learning curve. The crews are new to it and you're sorting things out." Once both TBMs passed through the frozen zone the freeze plants were turned off for the area to thaw on its own and the pipes were removed. Adjacent properties and streets were monitored and to date, no significant settlements have been observed.

Beyond the mixed face conditions, the ground composition is extremely hard, requiring 15 000-25 000 lbf/in.² (103-172 MPa) to drill through Manhattan schist, granite and some pegmatite intrusions. Advance rates ranged between 20ft (6.1m) and 40ft (12.2m) a day. Cutter disc wear rate varied, with most frequent changes occurring in the pegmatites - the hardest rocks - explains Wahl.

Overall on the project the TBMs each averaged 25ft (7.62m) a day, placing pre-cast concrete lining rings as permanent liner as they progressed. Manufactured by Technopref, the 5-ft (1.52-m) wide segments are in a five segment plus keystone configuration, 12in. (305mm) thick and wire reinforced.

Below: Disassembling one of the two TBMs used to bore the tunnels. Visit our digital edition to watch one of this summer's 7 Line extension breakthroughs



Above: Formwork at the 34th Street Station's mezzanine, looking south

Picking up the pace

There have been a number of factors driving the project six months ahead of schedule, including the good fortune that overall construction has gone well. A New York City Transit shaft located in the 8th Avenue and 41st Street section had originally been cleared for the contractor to use for personnel access.

"They agreed to remove some intermediate slabs and that allowed the contractor to use that shaft to bring equipment and materials down," explains Shawn Kildare, the MTA's program executive for the project. "Now that shaft allowed them to finish up all the work in the tail tracks, about a year and a half, two years ahead of schedule. If we didn't have that shaft, we would have to rely on New York City Transit

work trains, and there is a limited number of work trains that you can use on the line because you disrupt service."

One of the significant contributions to the project's progress was the TBMs finishing earlier than expected. Kildare attributes this to changing a shaft that had initially had two elbow connections. Modifying that to a straight connection allowed the contractor to use it for drill and blast operations for the 34th Street Station. "Having an additional shaft created a ripple effect for the project," Kildare says.

Consisting of two components, an upper mezzanine level and a platform level, the station was originally slated for drill and blast in the upper portion and the TBMs excavating the lower one. But the contractor was able to make good progress with the extra shaft, and the ground behaved so well that drill and blast was used for the platform area too.

Once the excavation finished, in October 2009, the TBMs, staggered by no less than 100ft (30.5m) as required by the contract, could be walked through the cavern to the north, explains Wahl. "So the first TBM came through, they disengaged it from the trailing gear, moved it toward the centre of the cavern and then pulled it forward on rails. And then the trailing gear followed."

This arrangement allowed the contractor to continue with concrete works within the cavern while the TBMs were being passed through, and the mucking operations to travel through the cavern during the concrete works. For muck removal the TBMs each had six buckets in the gauge area, four cone buckets and two backward buckets. Mulhauser muck cars transported the material to a vertical belt, which raised it



Above: Looking east to the existing 7 Line tracks

up the launch shaft to dump trucks for disposal in New Jersey.

Another time advantage came from the Port Authority of New York and New Jersey, which allowed the contractor to work 24-hours-a-day rather than limit night hour working as initially arranged. The 200ft by 50ft by 40ft (61m x 15m x 12m) TBM

reception chamber excavated by drill and blast in 2009 is adjacent to the current terminus for the No. 7 line and just below the Port Authority Bus Terminal. Drill and blast operations underneath the Port Authority Bus Terminal's basement, where buses load passengers, were carried out around the clock, saving time and avoiding

the need to stop, clean up, shut down, reopen and set-up again. "Now that particular section is nearly two years ahead of schedule," says Kildare.

During the project, there weren't any issues with settlement and local buildings, says Rosteck. "We did preconstruction surveys and there was an extensive instrumentation programme dictated by the contract so that we could check this and verify that we aren't getting settlement."

The TBMs each broke through in June and July and are being partially dismantled and backed up to a shaft excavated at 35th Street and 11th Avenue for removal.

Now the project will see three smaller core and shell contracts up for bid. These will provide ventilation, traction power substations and the primary station entrance. One was awarded in July to CCA Civil-Halmar International Civil Construction in July to mine and line a shaft/adit and construct a 2-storey ventilation building. Two other contracts are in the bidding phase, with due dates in late August and September.

MORETRENCH

- Dewatering & Groundwater Control
- Ground Freezing
- Earth Retention & Anchors
- Deep Foundations
- Underpinning Systems
- Grouting & Ground Improvement
- Environmental Remediation
- Industrial Construction

#7 Line Tail Tunnel, Ground Freezing

MORETRENCH.COM • 800-394-MORE

New Jersey • Florida • New York • Massachusetts • Pennsylvania • Delaware • Washington, DC • Wisconsin • Iowa

1. DEFAULT SECTION

1. What percentage of tunnel projects require waterproofing?

- Under 10%
 11-25%
 26-50%
 51-75%
 More than 76%

2. Is there a difference in the tunnel projects you work on between waterproofing and vapor intrusion protection?

- Yes - 2 Completely different approaches
 Yes - though we handle them nearly the same
 No

3. On tunnel projects, what waterproofing technologies has your firm utilised?

(You may select more than one)

- Spray applied (polyurethane, polyurea, other)
 Membrane (Bentonite)
 Membrane - Welded/Taped (PVC, Thermoplastic)
 Treated Shotcrete or Concrete
 Drainage only
 Other (please specify) _____

4. What type of waterproofing products are used for specific tunnelling methods (i.e. TBM or NATM or Cut and Cover)?

	TBM	NATM	Cut and Cover
Spray applied	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Membrane - Bentonite	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Membrane - PVC/Thermoplastic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Treated - Shotcrete/Concrete	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. Where are the causes of tunnel waterproofing breaches?

- Joints
 Membranes
 Applicator Error
 Material Selection
 Soil Contamination
 Other (please specify) _____

6. How does the type of tunnel work your firm does break out?

	Less than 10%	11-25%	26-50%	More than 51%
Sewer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rail	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Automobile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify) _____

7. In your area do water/sewer tunnels utilise:

	Water Retention Linings	Anti Corrosion Linings
Yes	<input type="radio"/>	<input type="radio"/>
No	<input type="radio"/>	<input type="radio"/>

8. What waterproofing technologies have been used on tunnel projects (all construction methods) successfully by your firm?

- Bentonite
 Thermoplastic/PVC liner
 Crystalline/Cement-based
 Spray Applied
 Other (please specify) _____

9. What methods have been use to address water ingress when a membrane or waterproofing system has been breached?

**10. What role does the soil/ground type play in waterproofing product selection?
For instance, do soft soils utilise one technology over the other and hard soils similarly?**

- Soil type is most important
 Soil type matters about 50% of the time
 Soil type has no impact on our waterproofing product selection
 Other (please specify) _____

11. When it comes to waterproofing your tunnel:

	Not Important	Somewhat Important	Important	Number One Priority
Cost of the Product	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Total Installed Cost of the System	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Warranty of Product	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Warranty of the System	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12. When thinking about waterproofing and tunnels - How Important is:

	Not Important	Somewhat Important	Important	Number One Priority
Waterproofing cost to the overall contract value of the project	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Waterproofing warranty on tunnel projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Approved Installer of Waterproofing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Manufacturer Supplied Engineering Support - Design Phase	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Manufacturer Supplied Engineering Support - On Site	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. Who typically installs waterproofing products and systems on a tunnelling project?

- General Contractor
 Waterproofing Contractor
 Concrete Contractor
 Concrete Repair Contractor
 Manufacturer of Waterproofing
 speciality Contractor
 Other (please specify) _____

14. What is the single biggest challenge your firm faces when it comes to waterproofing a tunnel?

15. Could you please share a little bit about yourself?

This question is optional. If you provide your email we will provide you with updates a couple times per year on tunnel technology advancements. You may opt out at anytime. Thank you for your time today.

Name: _____

Title: _____

Company: _____

Address: _____

State/Province: _____

ZIP/Postal Code: _____

Email Address: _____

How many years have you been in the tunnelling business?

You can also fill in this questionnaire on-line by login onto our website: www.tunnelonline.info

Please post to: Tunnels Editor, John Carpenter House, John Carpenter Street, London, EC4Y 0AN

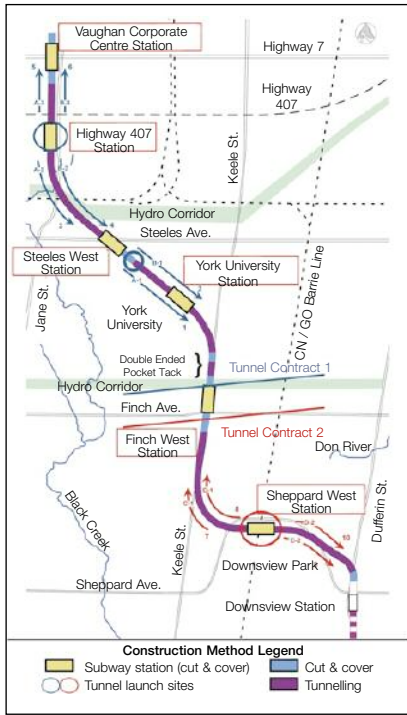


Rushing ahead in Toronto

Expansion of the Toronto subway system is progressing rapidly as lessons learned from previous extensions propel the network forward. Bernadette Redfern reports

As contractors prepare their final bids for the two major tunnelling contracts that are critical to the 8.6km expansion of the Toronto

metro, client Toronto Transit Commission (TTC) is busily overseeing preparatory works which will ensure that the new line and six new stations are complete by the



end of 2014. "It is a very tight schedule and we are committed to a revenue service date of late 2015," explains TTC construction supervisor Alan Boden. "Tunnelling has to finish to support the installation of trackwork, systems and station build out so the only way we could guarantee that and ensure that the EPB machines were available at end of the design period was to get them manufactured ourselves."

TTC is no stranger to tunnelling works.

The City of Toronto is home to the country's first ever metro subway line which was completed in 1953 and ran along the centre of the city from Union Station to Eglinton Station. Over the next 50 years the line expanded to become a network that today has 70 stations dotted along 70km of track, spanning the city both north to south and east to west. The last extension was a 5.5km line with five stations running east to west between Sheppard-Yonge and Don

Mills. On this contract TTC procured two TBMs directly from Lovat and saw the benefits of direct action. The same strategy is now being used on the latest extension and along with the EPB machines, procurement of the 9000 Armtec tunnel liners has also been undertaken by TTC. These are now being manufactured in nearby Woodstock.

A head start

Such measures are set to give the successful contractors a headstart once the contracts are awarded. Seven contracting ventures are in the running for the contracts including Spain's Dragados, Spain's FCC Construction, a joint venture of Italy's Impregilo with US Healey, the North American JV including McNally /Kiewit/AECON International with local Akon Contracting, Spain's OHL, Austria's Strabag and Japan's Obayashi with Flatiron Canadian Kenaidan.

The two contracts cover a total of 6.7km of twin bored tunnels with the CAD 250M (USD 238M) southern package also incorporating Shepherd West station, four cross passages and two extraction shafts. The CAD 350M (USD 333.5M) northern package includes SECM (NATM) construction of a double ended pocket track housing structure where trains can be turned at peak time, compensation grouting for the south end of the new station at York University along with three cross passages and two extraction shafts. "The reason for compensation grouting is that the station within the York University has buildings either end of the station and the Schulich School of Business at the southern end was borderline for tunnelling induced ground settlement. Predicted behaviours showed that the settlement needed to be arrested with, compensation grouting was the recommended method," explains Boden.

Awards for the contracts are just weeks away with the tender for the southern contract closing at the end of September and the northern section at the end of October. "All of the contractors were prequalified earlier this year. And [we] invited them to qualify as station contractors, EPB tunnelling contractors and then specialist sub contractors for compensation grouting and Sequential Excavation Method (SEM) tunnelling," says Boden.

Geology

The SEM tunnelled section is a modification to the original plans as the triple track required to turn the trains was originally housed at Steeles West station that Boden

Key dates

Feb 2005:	Toronto City Council passes motion that extension is priority expansion project
Aug 2005:	York Region Environmental Assessment (EA) submitted to Ontario Ministry of the Environment
Feb 2006:	Toronto EA submitted to Ontario Ministry of the Environment
Mar 2006:	Province of Ontario announce CAN 670M (USD 638M) trust fund to finance the project
Mar 2007:	Federal government announces CAN 697M (USD 664M) funding package
Oct 2007:	Executive Task Force established
Dec 2007:	Province of Ontario pledges an additional CAN 200M (USD 190.6M)
Feb 2008:	TTC awards first contract for the Steeles Ave West Sewer relocation
Mar 2008:	Federal Canadian Environment Assessment Agency approval received for the entire project from Transport Canada. Project management role awarded to Spadina Link JV (Hatch Mott MacDonald/Delcan/MMM group) and Project Controls role awarded to Stantec
Apr 2008:	Official project start date. Project management role awarded to Spadina Link JV (Hatch Mott MacDonald/Delcan/MMM group) and project controls role awarded to Stantec
Oct 2008:	Design contracts awarded to The Spadina Group Association, Arup Canada, and EarthTech Canada (AECOM). Geotechnical consultancy contracts awarded to Golder Associates and Inspec-Sol
Nov 2008:	Twin tunnel design contract to Hatch Mott MacDonald
Dec 2008:	Awarding of geotechnical engineering consultant to Coffey Geotechnics
Jun 2009:	Announcement of artists for station design collaboration with each station design consultants. Six individual finalists selected
Jul 2009:	Awarding of TBM contract to Lovat
Dec 2009:	Construction Information Session held for contractors Contract awarded for the supply of precast concrete tunnel lining to Armtec Holdings
Mar 2010:	Construction management services contract awarded to Morrison Hershfield Contract awarded for the TBM launch shaft at Steeles West Station to HC Matcon
Apr 2010:	Contract awarded for TBM launch shaft at Sheppard West Station to Varcon Construction
May 2010:	Contract awarded for condition surveying and monitoring consultant to Trow Associates
Jun 2010:	Contract awarded for Fire Hall #141 to Trumbley and Hampton Inc. Contract awarded for advanced enabling works Highway 407 Station to B. Gottardo Construction
Aug 2010:	First main tunnelling package for Shepherd West Station and southern tunnel tendered
Sept 2010:	Second main tunnelling package for northern tunnels, compensation grouting and SCM section to be tendered
Oct 2010:	Southern tunnel package award expected
Nov 2010:	Northern tunnel package award expected
Feb 2011:	Finch West and Vaughn Corporate Centre Station award expected
Mar 2011:	York University and Steeles West Station award expected
End 2014:	Construction complete
End 2015:	Toronto-York Spadina subway extension opens

The northern bore will have to cope with a high water table and granular deposits



refers to as a “monster.” Instead the team decided to rationalise the station box by housing the turning point in a DEPTHS located south of the York University Station. “This allows every second train to be turned back at peak periods. We looked at various ways to construct it, with EPB or combinations of EPB with SEM but we decided that it was best to do it all in SEM and so the machines are not tied up by this construction,” Boden explains.

The ground conditions here are stiff clay making it a favourable location for SEM. Along the rest of line ground conditions are all in glacial deposits. Most of the tunnelling is in a very hard schist stiff lower till, or in the very stiff upper till. In places the upper till and lower till are separated by a sand and silt layer, which becomes more prominent and more granular moving north. “The ground water table is within a metre of the surface throughout the alignment so while we have cohesive material it is not so problematic, but the further north we go where the granular

material is, there we will face challenges with water issues,” says Boden. In addition the granular material could also contain boulders of any size. “By and large the upper till and lower till are well known geological features to this part of Toronto. The Shepherd Line was constructed in very similar ground conditions but what makes it more of a challenge is the high water table and the granular material further north.”

As EPB machines are being used for the tunnel bores, water ingress will only be an issue for the six station boxes. The team is therefore considering combinations of secant piles and secant pile head walls. “As we move north towards Vaughan we may need to look at some form of bentonite slurry cut off wall,” says Boden.

Stations

Station contracts are set to be awarded in the first quarter of 2011 but a range of other enabling contracts are already underway, such as traffic management

and utilities diversions. Key to the programme delivery however is the early construction of the TBM launch shafts for the southern and northern sections. “The project has been very busy for the last 12 months with a series of early construction contracts required to give us a head start on the programme. Two launch shafts are underway, the first to the west of Shepherd West Station on the south tunnels and the second south of Steeles West Station,” says Boden.

These rectangular 22m deep box shafts were awarded to local contractors in March and April. With the south section extending 45m and the second 55m as this is sitting in the future cross over box at Steeles West giving the team more space.

An added complication that the TTC has to contend with is the multi-regional dimension that this particular section of the metro has. Unlike any of the other spurs the new northern link, which runs past York University and on to the City of Vaughan moves from being part of Toronto City to

Pre-qualified companies

Contractors have prequalified for the two main tunnelling contracts, and four station contract. Each tunnelling contractor entity has also qualified an SEM team. Four teams are prequalified for the compensation grouting section.

MAIN STATIONS (Category A)

AECON BUILDINGS	2 teams
BEFOR CONSTRUCTION	1 team
BONDFIELD CONSTRUCTION COMPANY LIMITED	1 team
DRAGADOS CANADA INC	6 teams
ELLIS DON	3 teams
FCC CONSTRUCCION	2 teams
IMPREGILO / HEALY	2 teams
LEDCOR CONSTRUCTION/ FLATIRON CONSTRUCTORS J.V	4 teams
OHL CANADA / BIRD	2 teams
PCL CONSTRUCTORS INC.	2 teams
SPADINA STATION CONSTRUCTORS (Kenaidan/Obayashi)	2 teams
TORONTO SPADINA CONSTRUCTORS (Obayashi/Flatiron/Kenaidan)	1 team
VANBOTS	2 teams
WALSH GROUP	1 team
YORK SPADINA CONSTRUCTORS (Flatiron/Obayashi/Kenaidan)	1 team

TUNNELS (Category B)

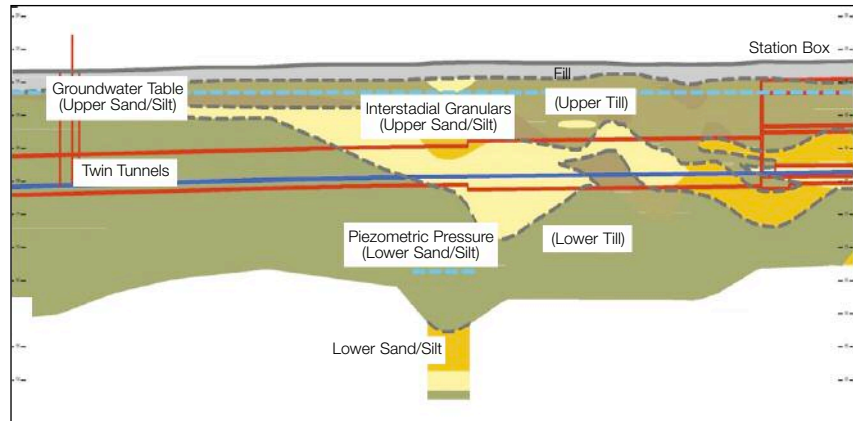
DRAGADOS CANADA	2 teams
FCC CONSTRUCTION	2 teams
IMPREGILO / HEALY	2 teams
MCNALLY / KIEWIT / AECON	2 teams
OHL CANADA	2 teams
STRABAG INC.	2 teams
TORONTO SPADINA CONSTRUCTORS (Obayashi/Flatiron/Kenaidan)	1 team
YORK SPADINA CONSTRUCTORS (Flatiron/Obayashi/Kenaidan)	1 team

SEQUENTIAL EXCAVATION METHOD (Category C)

DRAGADOS CANADA
FCC CONSTRUCCION
IMPREGILO / HEALY
MCNALLY / KIEWIT / AECON
STRABAG INC.
TORONTO SPADINA CONSTRUCTORS (Obayashi/Flatiron/Kenaidan)
OHL Construction Canada

COMPENSATION GROUTING (Category D)

ADVANCED CONSTRUCTION TECHNIQUES
DRAGADOS CANADA
HAYWARD BAKER INC.
STRABAG INC.



Above: A geological section of the project

being part of the Regional Municipality of York Region. "It is the first time the TTC has developed outside of the city boundary so there are some interesting challenges associated with obtaining land and permits but by and large it has all gone pretty smoothly," says Boden.

This explains why the CAN 2.01bn (USD 1.92bn) financing required has come from a variety of sources, from the Canadian federal government (CAN 697M [USD 664M]), the Ontario provincial government (CAN 670M [USD 638M]) and then from both the City of Toronto and the Regional Municipality of York. An executive task force of representatives from both regional and provincial government has been established to oversee the project which extends into York Region to provide high

quality rapid transit service in the fastest growing region in the Greater Toronto Area. It is set to take 1,700 buses per day off the roads of Ontario. These currently serve the influx of students attending York University, which stands to benefit greatly from the new metro line known as the York University Line. This extension will also benefit York University's Keele campus as the community of 40,000 plus people will have a station within the heart of the campus to ultimately reduce the need for bus service.

Looking ahead the next few months are going to be very busy for the TTC, which has major contracts to award alongside the supervision of the works already underway and preparation of tender documents for the stations. But with nearly six decades of experience on metro construction these challenges are being taken in TTC's stride. ▀

Above: Construction is set for completion in 2014





Please visit our new website at www.miningequipmentltd.com

PROVEN

Offering new and used tunneling equipment for more than 25 years.

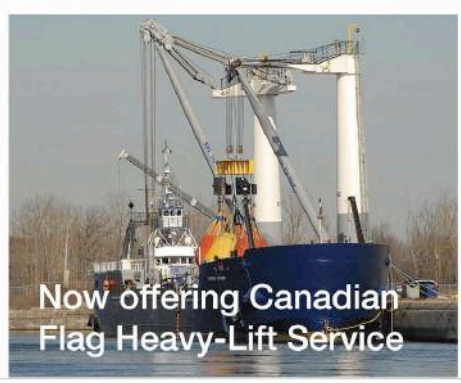
- Locomotives
- Rolling Stock
- Scooptrams
- Drill Jumbos
- Mine Hoists
- Stage Winches
- Ventilation Equipment



Phone: (970) 259-0412 | Fax: (970) 259-5149 | www.miningequipmentltd.com



Solutions to Project Cargo Movements Start Here



Now offering Canadian Flag Heavy-Lift Service

ROHDE & LIESENFELD CANADA INC

1600 Sun Life Plaza, West Tower
 144 - 4th Avenue SW
 Calgary, AB T2P 3N4
 Telephone: (403) 514-6907
 Fax: (403) 269-3537
 Email: info@rolcanada.com

JOB of the month

Exciting opportunities for mid and senior tunnel professionals for a variety of positions

LOCATION: NORTH AMERICA

For more information visit: www.tunnelsonline.info



Messe München
International

Welcome to bauma China 2010.

bauma China 2010

23 – 26 November, Shanghai

SHANGHAI
NEW INTERNATIONAL
EXPO CENTRE

**REGISTER
NOW!**

bauma China is the leading trade fair for Construction Machinery, Building Material Machines, Construction Vehicles and Equipment in China and Asia.

bauma China offers:

- 1,700 exhibitors from over 30 countries
- 220,000 square meters exhibition space
- 120,000 visitors from 120 countries expected

**BUILD
ON
GROWTH**

www.bauma-china.com

Straight down the middle

When a major city that is still growing is bound by water on three sides traffic congestion seems inevitable. In the case of San Francisco even a widespread public transport system of many types has not been able to hold off the need for more route investment. The Central Subway to Downtown and Chinatown is the latest project to aid those wishing to reach the centre of San Francisco by filling a gap in the network. Maurice Jones reports

The reasons for the San Francisco Municipal Transportation Agency's (MuniMetro) Central Subway project can be viewed from several aspects, but all in common with the need to provide a better public transport to the densely developed Downtown Financial District and Chinatown areas of the city. San Francisco has had a long but discontinuous history of public transport, especially featuring its famous cable cars on its hilly streets, a few routes of which are preserved. The ever-present hills and increase in road traffic make a more efficient system vital.

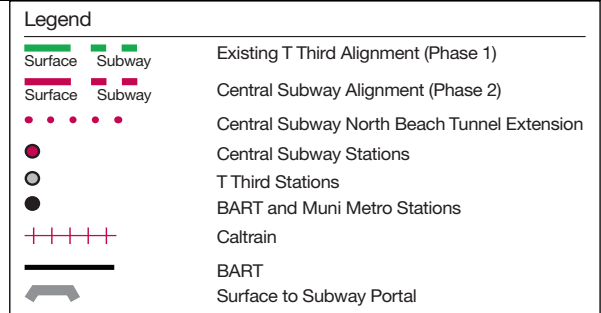
The Central Subway is designated as Phase 2 of the T Third Light Rail Project. Phase 1, or the 6.9 mile (11km) long Initial Segment has been running since April 2007. It goes on the surface from the southern suburbs of the city to link into the Caltrain Terminal and then hugs the shoreline to the famous Embarcadero waterfront and bay ferries where it goes underground before taking a 90 degree left turn to run along Market Street, one of the city's main thoroughfares, and the original MuniMetro. This results in a big loop in the route, which will be short-cut by the Phase 2 Central Subway.

The 1.7-mile (2.7km) Central Subway route leaves Phase 1 at the Caltrain Terminal station at Fourth and Brannan Streets on the surface to plunge beneath the Interstate highway route (to the Bay Bridge) at a portal and continue along Fourth Street to Market Street/Union Square where it interchanges with the MuniMetro and the Bay Area Rapid Transit (BART) regional route. After this point it then continues along Stockton Street to the new Chinatown Station at Jackson Street. There are also outline plans for an underground extension of the route to link with the North Beach suburb, but not as part of this project (figure 1).

There is currently no rail route servicing central San Francisco in a generally north-south direction. Not only do private vehicles congest the area, but bus services are also



Above: Fig. 1 – Map of central San Francisco showing the route of the Central Subway and links with other transport routes



overcrowded. One of the major expected benefits of the Central Subway is a reduction in travel time between the Caltrain Terminal and Chinatown from 20 minutes by

bus to 8 to 10 minutes by the metro.

In addition to this central function, the Central Subway will provide regional connections via Caltrain, BART and the T

Third Phase 1 from the outlying communities of Mission Bay, Bayview and Hunters Point.

Apart from convenience, the Central Subway should also offer the environmental benefits about which California is famously keen including reduced air and noise pollution. Forecast ridership is expected to reach 76 000 by the year 2030.

Funding

Phase 2 or Central Subway project funding will be drawn from federal state and local resources, currently amounting to USD1578.3M. Although the federal funding, 48 per cent of the total, has been planned,

Below: Site of the launch portal adjacent to the I-80 flyover



it has not actually be allocated formally yet. Nevertheless the program is proceeding on the assumption that funding will be made. Of the rest, 29 percent is due to come from city/local sources and 23 per cent from the state of California. Full funding agreements are expected at the end of 2011.

Construction tasks

Although comparatively short, the Central Subway route is mostly underground and faces many construction challenges including the famous San Francisco topography, the need to maintain support of many adjacent surface structures and

the need for seismic engineering.

Separate contracts are being or have been let for site investigation, preparatory works, the tunnels, and four stations.

The twin-bore running tunnels, each 1.6 miles (2.6km) long, are to be driven by two earth-pressure balance (EPB) TBMs simultaneously from a portal site now being prepared on Fourth Street, located between a new surface station platform at Fourth and Brannan, and the Interstate I-80 flyover. The tunnelling contract bid invitation, with an estimated cost of USD200M, will be advertised in Q4 this year with a scheduled first notice to proceed in March 2011. The work is expected to last 40 months and will be the first major contract to be bid.

Luis Zurinaga of the project management joint venture, Zurinaga-Cordoba, working for the San Francisco MTA, explained some of the scheduling difficulties to *T&T North America*. The first notice to proceed with tunnelling, once funding guarantees have been obtained, is essentially clearance to procure the TBMs in advance by the successful contractor to allow for manufacturing lead times. "We don't want to wait until full funding has been received," he says, "or that will mean project delays. So the first notice will be to acquire the TBMs, the second will be for preparation of the TBM launch shaft, and the third to launch the TBMs. The successful bidder will also have the option to use only one TBM if it shows it can meet the schedule. In order to keep things going we've already let one contract to move utilities at the launch pit and Moscone Station, and there will be a second utility diversion contract let soon for Union Square Station."

The TBMs will install a one-pass precast concrete segmental lining, passing through the station areas before they are constructed. Between Market Street and Chinatown the tunnels make a steep incline to follow the surface topography and pass adjacent to part of the Stockton street tunnel, which is nearly 100 years old. In this area of high ground the geology is mainly fractured rock.

As with the rest of the San Francisco Bay area, the geology is a real mixture necessitating extensive site investigation. The tunneling horizon is mainly in sands and superficial deposits together with weak rock of the Franciscan Formation. Ground control is particularly important, especially where the water table is relatively high. Here no dewatering is allowable, as this would create further instability in the overlying marine clays. Consequently extensive monitoring for possible subsidence along the route, as well as adjacent to stations, is

needed, with over 250 buildings being fitted with instrumentation.

There is a wide variety of buildings including historic monuments and conservation areas as well as those of commercial importance. Zurinaga commented, "There needs to be significant pretreatment of the ground, especially near old structures and the BART tunnels which are within five feet (1.5m) of the new tunnels. The work will include compensation grouting. We are prepared to install pipe roofs but hopefully they will not be needed."

Other geotechnical support measures expected to be considered include jet grouting and chemical grouting, as well as sprayed concrete and NATM procedures for the sequential excavation areas.

Other work included in the tunnelling contract will include construction of the TBM launch box and retrieval shaft near North Beach, 'end walls' at Moscone and Union Square/Market Street stations, six cross passages, settlement monitoring and the protection of existing utilities, surface structures and the BART tunnels.

Zurinaga explains that the current plan is to abandon the TBM shield(s) at the end of the drives and retreat back with the TBM operational and trailing gear. "The alternative is to construct a retrieval pit, but it may be cheaper for the contractor to abandon the shield," he says. "It will be up to them."

The planned contract is of a standard bid and construct type, with the design being given to the contractor, but alternatives are being examined. "Shared risk is being looked at," reports Zurinaga, "in order to reduce costs. We are absolutely open to contractor cost engineering ideas."

Stations

The route includes three underground stations that are major construction works in their own right. From the south these are Moscone, Union Square/Market Street interchange and Chinatown, of which Union Square/Market Street is the largest. All have access routes using vertical lifts for use by the disabled as well as stair and escalator access. All also include substantial works for support of adjacent structures, with final designs still being drawn up. Zurinaga says that designs are in the nature of 'this is the way you could do it,' with the final decisions on methods left to the project governing board.

At an estimated cost of USD170M, the Union Square/Market Street Station contract will be the first station work to be put out to tender, approximately a year after



the running tunnel in Q4 2011. The work, which is expected to last 56 months, includes the installation and commissioning of station services as well as civil work. Commenting on this Zurinaga says, "All parties agree that the Union Square work is the most critical in several ways. The area has 'high end' shops and other commercial premises so site housekeeping is very important. There will be restrictions on noise and vibration generation, plus limitations on working hours. Except for the tunnelling itself there will no work at the Christmas shopping time and other holidays, nor at nighttime. These environmental points were important to obtain agreements to go ahead."

The new station box, 225ft (68.6m) long and at a depth of 100ft (30m), will be constructed by a combination of secant pile walls and cutter soil mixing for

stabilization, a process innovative in the US. The box will reach groundwater level under the BART station necessitating water control precautions.

Excavation within the box will be by top-down and sequential excavation methods, mining sideways from the access cut. In addition to the new station box, there will be connections to and modifications of the adjacent BART Powell Street. In the design of the station provision is being made for another possible MuniMetro line connection.

Up the incline at Chinatown the contract, at an estimated cost of USD 150M, is similar but also includes provision for AC and DC traction substations as well as station services. At a depth of 60ft (20m), the basic station box will be 200ft (61.0m) long, but will be extended to 340ft (103.6m) to allow for a crossover. Secant piles or slurry diaphragm walls will form the box walls with sequential method excavation between. The contract for Chinatown station will be put out to tender in Q1 2012 with scheduled notice to proceed the following quarter for a construction period of 52 months.

Moscone Station is the smallest of the three underground stations but has many of the same difficult construction features, especially in view of the proximity of surface structures that must not be disturbed. The estimated work cost is USD90M and will be out to tender at the same time as Chinatown station, with a scheduled notice to proceed during Q3 2012 with a duration of 49 months. The station box, 200ft (61.0m) long and at a depth of 50ft (15.2m), will be constructed using diaphragm slurry walls and top-down excavation. It is on the site of an existing gas station, so there may need to be precautions against leaked hydrocarbons in the ground.

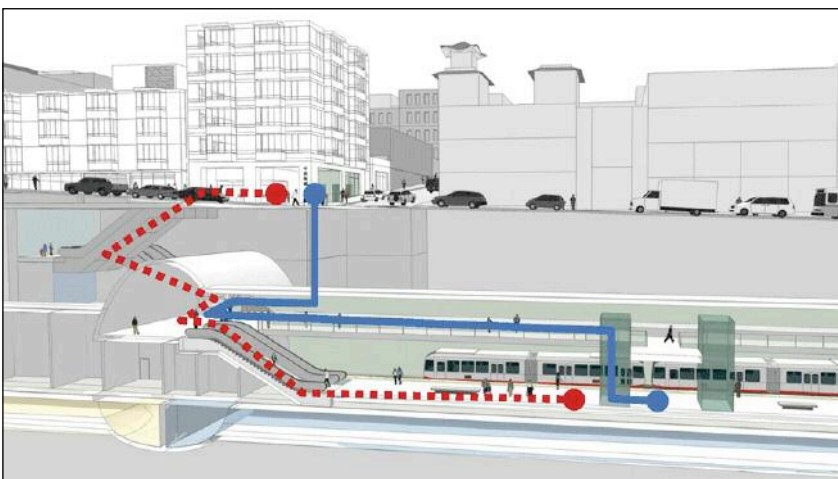
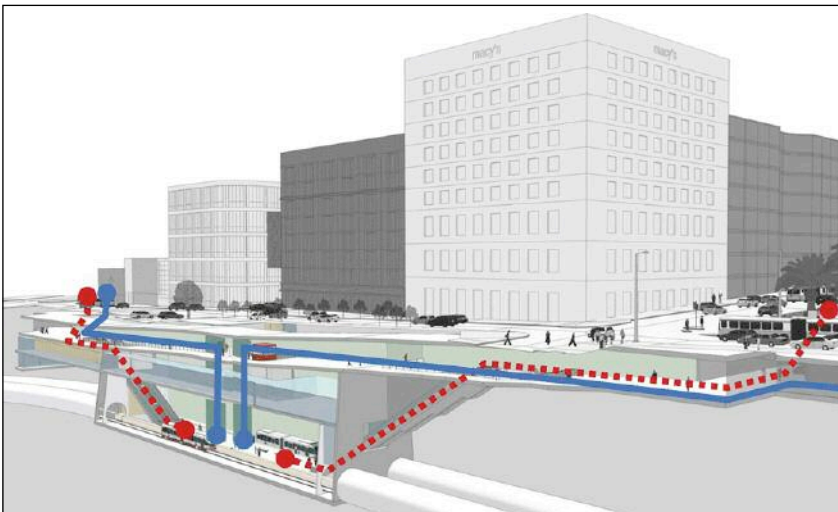
Schedule

In January the MTA received approval from the Federal Transport Administration to enter final design and notice to proceed was issued. Final design work, by Jacobs Associates and others, is under way and due for completion by the end of 2013. The authority also received USD 20M in further funding to support the project design work.

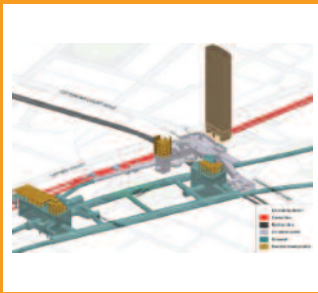
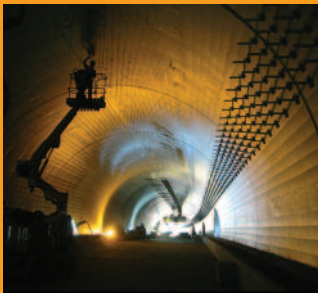
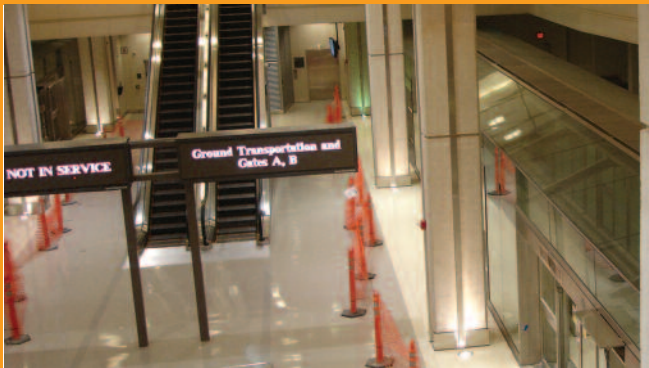
Preliminary construction activity has also started, with a groundbreaking ceremony taking place in February (see *Tunnels & Tunnelling International World News*, 25 February 2010). Utility relocation work to enable construction of the Moscone Station and the portal on Fourth Street between Howard and Brant Streets started in January.

Major construction is due to start from 2013 following full funding agreement. ■

Above: Luis Zurinaga, project management consulting engineer to the SF MTA; **Below, top:** Artist's impression of the largest station and interchange at Union Square/Market Street **Below, bottom:** Chinatown Station will provide much needed extra public transport to this and the North Bay communities



A World Leader in Geotechnics, Tunnel Engineering, and Tunnel Construction Management



- Tunnels
- Shafts
- Slopes
- Foundations
- Monitoring
- Investigation
- Groundwater
- Environment



Gall Zeidler Consultants, LLC
GEOTECHNICS | TUNNEL DESIGN | ENGINEERING

Washington, DC • New York, NY • Walnut Creek, CA •
Salzburg, Austria • London, UK • Singapore

www.gzconsultants.com

Monitor with confidence for Regulatory Compliance and Advanced Engineering

- Rugged cast aluminum case
- Ethernet communications
- RF and EMI Shielding
- IP67 water resistance
- CE Class B



Brisbane, Australia Tunnel: Photo by Erik9, creativecommons.org/licenses/by-sa/3.0/deed.en

Minimate Pro6™
Multipoint Vibration Monitor **InstanTel**

(613) 592-4642 • sales@instanTel.com • www.instanTel.com

Automated Grout & Slurry Systems

- Featuring high shear colloidal mills with new MkIV mechanical seals
- Fully Automated
- Self Cleaning
- Compact
- Use with Horizontal Bins or Conventional Silos
- Foam & Ad-Mix Systems Available
- Used by Major Civil Contractors and Mining Companies Worldwide



Kenny Construction
Brightwater Conveyance Project

Concept to completion



Tel: 604.556.7225
Fax: 604.556.7215
Sales@TeamMixing.com

New double life for Marin County link

It's always satisfying to give new, useful life to an old infrastructure resource, but if the 'life' is a double one, satisfaction is multiplied, even if it means a near reconstruction. Maurice Jones reports on how the old Cal Park Hill rail tunnel is being put to use

When most people think of rehabilitation they usually mean not much more than a makeover, and then rarely more than once. In the case of the Cal Park Hill Tunnel near the north shores of San Francisco Bay, this disused infrastructure link is about to commence a third and double life following its second reconstruction since originally driven as a single-track rail tunnel in 1886. This time reconstruction was necessary not only to transform its use, but also secure a roof collapse and other structural instability in the area.

The renewed passageway under California Park is now ready to accept pedestrian and cycle traffic on one side while the other side is set to start installation next year for SMART—the Sonoma Marin Area Rapid Rail Transit.

Both passages will facilitate residents' travel from San Rafael and other communities on one side of the Cal Park Ridge to the Bay area side and, in particular, the Larkspur Ferry to San Francisco and other Bay-side communities. This is also adjacent to the famous San Quentin federal prison.

History

Cal Park Hill Tunnel carried a single-track railroad from 1886 to 1924, when it was widened to accommodate two tracks. It carried passenger traffic until the 1950s and freight until the 1990s.

One of the tracks was removed in 1970 but continued tunnel use was halted by a fire in the 1990s fuelled by timber supports in the tunnel, resulting in the loss of around 30 per cent of the support. The fire burned on through the night and caused structural weakness that resulted in a collapse practically through to the surface and 300ft (100m) behind the south portal.

Then a portion of the tunnel some 8ft



(2.4m) long near the north portal caved in due to rotting timber supports. This 'sinkhole' even carried a tree down with it, while two smaller sinkholes had appeared near the south portal.

The tunnel has therefore been out of use ever since. Jacobs Associates were engaged to provide inspection and rehabilitation design services for the south end of the tunnel immediately following the fire, but to a limited extent for mainly safety reasons. In 1994 and 1995 the consultants were again involved to design repairs to the north portal and to install a new security gate. This was followed in 1998 by conceptual cost estimates for tunnel repair and stabilization to prevent further deterioration and collapse.

State of affairs

The tunnel is 1,100ft (335m) long, 21ft (6.4m) high, and was wide enough for the double-track railroad. It runs in the Franciscan Formation that, in this area, tends to contain more hard material

Above: Portal plaque indicates the dates of the last reconstruction—1924—and the latest—2010

although still very mixed and structurally weak. The materials are generally weak shale, sandstone and some bands of hard greywacke, although the tunnel collapses also contained soil mixed with the rock.

Fortunately the early post-fire actions above prevented total collapse and allowed the successful reconstruction. In the collapsed zones the mixture of hard and soft material made it very difficult to excavate safely without further structural deterioration.

An additional concern was the proximity of the 101 Highway that runs close to and practically parallel to the Cal Park Hill Tunnel. Caltrans (the California state transport authority) wanted no settlement to the carriageway and so stabilization of the embankments at the tunnel approaches as well as within the tunnel itself were high priorities.

Reconstruction

In 2008 Jacobs Associates was engaged to provide construction management services including project management, resident engineering, field inspection, independent quality control testing and office engineering. Ghilotti Construction won the contract to carry out site clearance, temporary support, ground stabilization, tunnel reconstruction to design and regrading of portal approaches for both the multi-use pathway and the railroad.

Due to the fire incident the owner and project managers were keen to remove all timber from the tunnel and to use only steel and concrete in its reconstruction.

Resident staff engineer with Jacobs Associates Erin Clarke explains that the contractor, Ghilotti Construction, was responsible for temporary support for working safety but that the type and degree of permanent support required was determined by the engineering team according to the conditions discovered. With the ban on timber, there is a reliance on steel arch ribs, sprayed concrete and in situ concrete.

"The contractor used mainly shotcrete over one to four sets of steel ribs at 4ft (1.22m) centers. There were also voids behind this support that had to be filled. The standard shotcrete support was two layers of steel-fiber reinforced concrete, each 4in (100mm) thick. There was up to 6ft (1.8m) of overbreak behind the steel sets in places. In these areas we used Stay-form panels, sprayed shotcrete over them and then filled behind."

AMICO Stay-form is produced by the Alabama Metal Industries Corp in galvanized steel sheets, ribbed and expanded, used as formwork, which is left in place. The special 'Shot-form' is a mesh specially designed for sprayed concrete to minimize pass-through and reduce rebound.

With the new grading of pathway and railroad bed carried out in advance of tunnel work, the reconstructed tunnel is



Top: The rail compartment of the Cal Park Tunnel showing sprayed concrete sidewall support and the concrete masonry divider to the pedestrian side (right) [Photo: Jacobs Associates – Sue Bednarz]; **Above, left:** Looking south through the completed multi-use pathway passage [Photo: Jacobs Associates – Sue Bednarz]; **Above, right:** Cal Park Tunnel south portal showing multi-use pathway transition structure [Photo: Jacobs Associates – Sue Bednarz]

now increased from 23ft (7.0m) high above grade to 28ft (8.5m), and 33ft (10.1m) total width. This allows for a 6in (150mm) layer of hardcore aggregate at the carriageway.

Pedestrian passageway

The pedestrian and cycle way passage of the tunnel is of sophisticated design with many features and equipment to improve the environment and security, so to encourage use. The division between this and the rail passage is built of concrete block masonry (CMU). This is designed to resist train noise at the full planned speed of 45 miles/h (72 km/h).

The rectangular section of the passageway changes to a transitional arch at each portal for user protection and light intensity transition. The opposite (rock) surface of the passageway is sprayed concrete with a trowel finish to remove rough surfaces.

A cable-carrying passage in the crown is formed of a deck of lightweight glass fiber-reinforced concrete. Two switchgear and control rooms have been formed along the side of the tunnel with adjacent cable-duct access points. These are made fully waterproof by a bentonite seal and have air conditioning installed. There is also an emergency power supply back up.

Equipment in the multi-use passage includes emergency phones (two linked to

stations in each direction), a linear heat detector also linked in both directions, fire-fighting equipment, CCTV cameras, and six fans in the crown for maintenance ventilation to remove any fumes, etc. Other communications include automatic dial emergency call out and a 'leaky feeder' radio booster for use by maintenance personnel and police Wi-Fi.

The path continues on the surface for a total of 2 miles (3.2km).

Rail route

The SMART rail link received county approval in March and is still on schedule for installation in the tunnel next year. The full route will eventually run 75 miles (120.7 km) to the north linking with Sonoma, famous as the place of first declaration of Californian independence from Mexico. From the south tunnel portal a new station will be built at Larkspur Ferry terminal.

Expectant users

When *T&T North America* visited the Cal Park Hill Tunnel there were (unsolicited) conversations on the Larkspur Ferry from San Francisco about when the tunnel pathway would eventually be opened—evidence of an expectant public with many wanting to be first through. But Clarke has been reported to say that she is determined to be first through on her bike!

Project summary

Project: SMART – Sonoma Marin Area Rapid Rail Transit

Owner: County of Marin

Construction project manager: Jacobs Associates

Structural design: URS

Tunnel design: EarthTech (now AECON)

Contractor: Ghilotti Construction

Project cost: Approximately USD 25M

Construction period: 2008-2010

TOUGH ROCK. TOUGH TBM.

When a tunnel project appears too challenging, it's a job for Robbins. The industry's most productive equipment, Robbins TBMs have completed more rock tunnels than all the competition combined. That means you have all the power and ingenuity you need to accomplish any hard rock project.

Move mountains with Robbins.

therobbinscompany.com
sales@robbinstbm.com

Robbins
GLOBAL LEADERSHIP. UNCOMMON EXPERIENCE.